ILLUMINATING ENGINEERING

MAY, 1950

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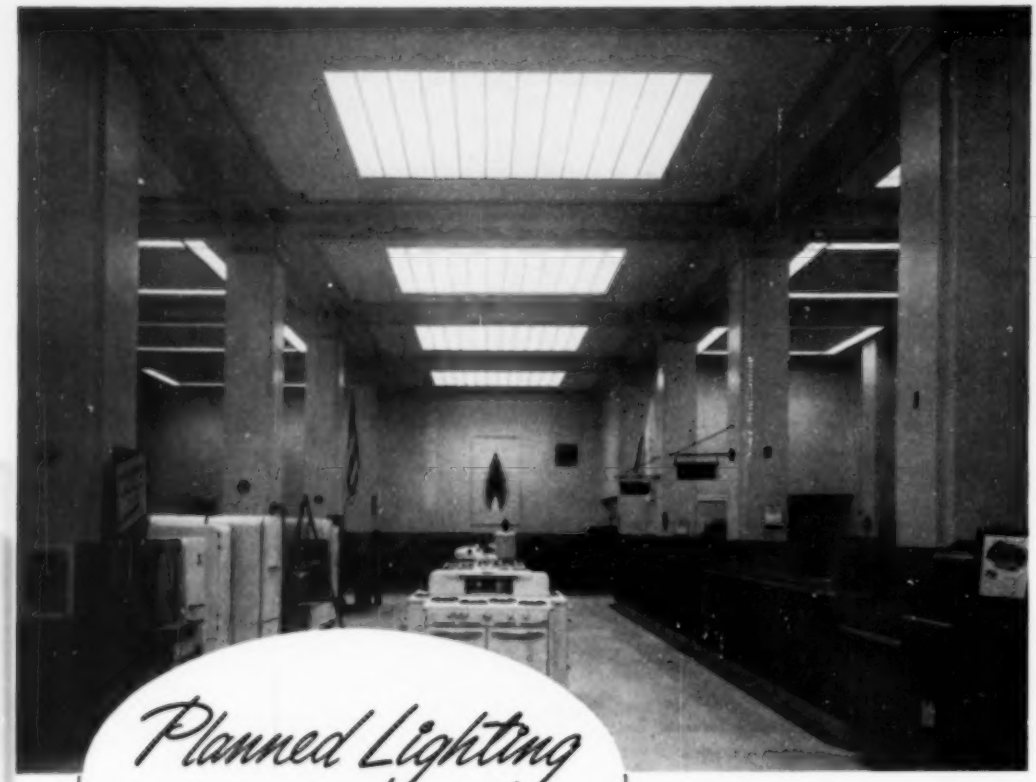

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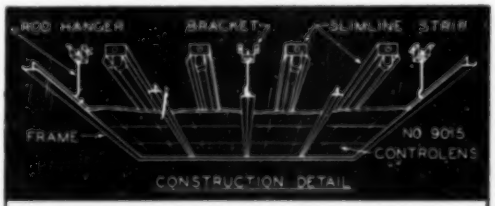

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ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

MAY
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the PUBLIC must be BETTER INFORMED on the importance of GOOD lighting equipment

As an industry, and as individual business men, we fail in selling PLANNED LIGHTING when we do not sell the importance of GOOD EQUIPMENT at the same time. It is our obligation that we keep faith with our customers by giving them the UNVARNISHED FACTS about the DIFFERENCE between GOOD and INFERIOR or SUBSTANDARD EQUIPMENT in terms of the factors listed below.

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These provide the buyer not only with the assurance that MINIMUM STANDARDS for performance have been met, but also that UNIFORM QUALITY is continuously maintained from one piece of equipment to the other.

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Architecture of Light

By C. L. CROUCH
Technical Director, I.E.S.

LIGHT IS a medium of expression. Consciously or unconsciously the lighting designer creates an atmosphere by his planned lighting design. Will that atmosphere produce the desired effect upon the occupants? Will there be a warmth of reaction to the designed interior? If so, happy is the lighting designer in the knowledge that he has made a worthy contribution to the values of living and working.

FOR YEARS the lighting engineer has been a slave to his concepts of efficiency. While he was diligently and laboriously harnessing the lumens to do their duty at the point of work, he was not prepared to comprehend fully the influence of the surroundings on performance of the task at hand. Recently, due to the availability of a more liberal supply of lumens produced from sources more flexibly adapted to room conditions, he has been emancipated from the rigors of his previous economy and is becoming increasingly conscious of the total room effect. Then, too, he learned during the early stages of the application of the new-found sources that the brightness relationships in the field of view had become critical as the levels of illumination were increased. He discovered that to eliminate glare he had to keep the brightness differences in the room within limits.

WITH THE advent of the new sources, the lighting engineer was confronted with color problems. The color schemes used with incandescent filament lighting appeared strange and unnatural under fluorescent lighting. Soon it was learned that other color schemes could be used to supplement or complement the light source color. New light sources were developed, resulting in a series giving predominance to various parts of the spectrum — the blues and greens for coolness of feeling, and reds and yellows for warmth, with several steps between. Thus, moods and appearances of people could be changed at will with suitable combinations of interior finishes and light sources. The lighting planner was challenged by a new horizon of color. This growing consciousness of the effect of the *total illuminated environment*, including both brightness and color, has opened up before the lighting man a revolutionary vista of new possibilities. What will he do with the situation? Will he continue to deal with just so much "brass, glass, and chain"? Will he dully consider lighting a matter of "filling a box with light" or perfunctorily getting an order for "whatever the traffic will bear"?

NOW IS THE hour for every lighting man and woman to awaken to the ambition of becoming *an architect of light*. We are dealing with the most powerful, dynamic, and dramatic medium of the universe. We can sway the reactions of the multitudes. We can set the mood of every interior — we can thrill with the dramatic; we can set up a brisk, efficient interior for work; or we can warm and relax the occupants in a sense of well-being.

WHAT TOOLS we have at our command! We have spot sources, linear sources, area sources, and control equipment of every kind. We have all the varieties and subtleties of color in sources, filters and room finishes. Do we have the skill or are we frustrated in the midst of every facility at our command? Skills come from patient attempts to execute the dreams of an inspired mind. Let us study the effects of light and color. Let us start now with every room plan that comes before us. Let us answer the questions: first, what is the purpose of this interior? and second, what combinations of light and color will carry out the feeling required? Let us design all the elements as an integrated whole. When the interior is completed and in operation, let us drop in and stay long enough to assess critically both the efficiency and effectiveness of the design. Slowly these experiences will develop skill in design "know-how" and a trained judgment.

A Planned Lighting Check Sheet

How Does Your Job Measure Up?

SCORE			CRITERIA
Good	Fair	Questionable	
100	50	0	**Exery lighting recommendation should be directly aimed at the single target-objective of providing an effective and economical lighting plan geared directly to the user's present and foreseeable needs. Although no single listing of objective criteria such as this will exactly fit all jobs or suit every individual taste, the use of such a check-sheet can be useful to all parties concerned.**
☐	☐	☐	**1. REQUIREMENTS—*Does the prescription fit specific needs?*** a. Were the various functions to be served in the area specifically analyzed to determine the lighting requirements of each—on horizontal, oblique, and vertical surfaces—in terms of I.E.S. recommendations? b. Were the physical characteristics of the area thoroughly considered—ceiling structural design, height, window areas, adequacy and flexibility of electric service circuits and controls. c. If for any insurmountable reason, the user cannot make a complete installation initially, does the recommendation provide for a logical step-by-step development toward a well-planned ultimate objective?
☐	☐	☐	**2. SOURCE—*Is the light Source best for the work?*** a. Considering the type of activity to be carried on in the area, are the proper daylighting control provisions made and are the proper lamps called for—incandescent, fluorescent or, mercury vapor, singly or in combination—and proper consideration given to color qualities? b. Is the plan best for the user in the matter of such points as first cost of equipment and wiring, energy consumption and cost, color of light, heating effects, lighting and relighting time, lag, effects of temperature and humidity, noise level, radio-interference?
☐	☐	☐	**3. LUMINAIRE—*Is the luminaire best for the job?*** a. Considering the nature of activity to be served, do the selected luminaires give suitable light distribution, proper brightness ratios and contrasts, proper control of specular reflections from possible polished surfaces, in the lighted area—according to I.E.S. recommendations? b. Do the luminaires properly harmonize with the general design and architectural treatment?
☐	☐	☐	**4. QUANTITY—*Is the level of illumination correct?*** a. Considering the relative severity and duration of visual tasks to be performed, does the design provide adequate amounts of light in the right places—according to I.E.S. recommendations—for "quick" accurate, and comfortable seeing? b. Does the design provide adequate flexibility to meet possible changing conditions and requirements?
☐	☐	☐	**5. QUALITY—*Is the quality of light right?*** a. Do the layout and the selected equipment assure proper brightness patterns and ratios between visually adjacent surfaces; does this apply to possible reflected images at point of work as well as to normal direct view of sources. Have I.E.S. recommendations been met? b. Do they provide suitable brightness ratios between the different architectural surfaces of the lighted area, between work and work surfaces and other room areas, or between displayed merchandise and background?
☐	☐	☐	**6. ENVIRONMENT—*Were surroundings considered?*** a. Whether in office, store, school, industry, home, or other service, the provision of adequate footcandles on a specific surface is only a part of the job providing adequate and satisfactory lighting for the user. Does the lighting plan give specific attention to such important matters as proper painting and the use of color for furnishings or equipment as well as for room surfaces? b. Is the plan appropriate to the characteristics of adjacent areas?
☐	☐	☐	**7. MAINTENANCE—*Is easy maintenance provided for?*** a. Do the plans provide for the maintenance program which is an inseparable part of any good lighting installation? Is it realistic from the standpoint of economy, personnel safety; and human nature? b. Has the user been specifically advised of the importance of proper maintenance in terms of the lighting results and costs that he can expect?

The Better the Score—The Greater the User's Assurance of Satisfaction.

Why Design for the Best in Classrooms?

By GEORGE P. WAKEFIELD

A FORTY-EIGHT page booklet, *The Co-ordinated Classroom* by Darell Boyd Harmon, devoted to classroom lighting, seating, and decoration was recently distributed to some 76,000 school authorities and architects. It presented principles and methods of providing an ideal environment for students to grow, physically and educationally. The reaction from one eminent lighting engineer to the detailed presentation was "why plan for such perfection?"

It seems to me that there is a sound reason why 100 per cent perfection should be planned into *all* schools. The reason is: when the building is being planned and while it is being constructed there is bound to be such a dilution from perfection that by the time the classroom is occupied compromises with finances, materials, customs, and prejudices will automatically eliminate at least a quarter of its most desirable qualities. In fact, with so many people and other factors involved in planning and constructing a public building, policing the original specifications becomes a real chore.

Recently I had an opportunity to observe this dilution at work. This was in an addition being planned for the Vermilion, Ohio, public school. Although two illuminating engineers from our company were on the school board, one as president, we almost lost control of the daylighting because the architect wanted to continue the same type of fenestration as in the old section in order to assure uniformity of design with the main building — of 1929 vintage. However, he readily agreed to glass block with a vision strip after he appreciated more fully what we were attempting to do.

When the plans were finished, a large roll of blueprints was dumped on the board's table for approval at the regular two-hour session. As conscientious as a school board member may be, it is impossible to check all details on such a large project in one board session. Nevertheless, the plans were approved, the building started. Still more dilution started from there.

MR. WAKEFIELD is with the F. W. Wakefield Brass Co., Vermilion, Ohio.

Dilution During Construction

Here are some of the things which came up during the construction.

(1) *Flooring:* darker than specified, lighter materials not available at the time of building.

(2) *Polished Marble Sills:* continued from the design of the earlier building provided a mirror surface which is highly objectionable both as a source of glare and as a projected distracting pattern on the ceiling.

(3) *Lockers:* in the back of the room in dark brown finish. The Contractor failed to specify light-

Figure 1 (Left). Afternoon view, west exposure showing direct sunlight through vision strip and reflected brightness pattern from polished marble sills. Figure 2 (Right). Undecorated room. Note dark green steel frame around fenestration.

Figure 3 (Left). Decorated room. Floor remains slightly out of balance for American Standard Practice for School Lighting. Vision strip not yet corrected. Figure 4 (Right). Suggested improvement to reduce sky-brightness through vision strip is to mount venetian blinds as shown above.

er finish for these otherwise obtrusive objects.

(4) *Steel Supporting Beam:* and framework around glass block painted dark green to harmonize with sash of the old building. This provided a sharp contrast between the light glass block and the adjoining surfaces.

(5) *Decoration:* lack of funds at the end of the project prevented rooms from being decorated at all. Light acoustical plaster was used throughout the building and left unpainted.

(6) *Vision Strip:* for the same reason, venetian blinds were not put on the vision strip, so that excessive sky-brightness became objectionable on the west side in the afternoon.

(7) *Desks:* the most exasperating experience of all. The correct type of natural finish desks had been ordered with a dull non-glare finish, but as soon as they were unpacked, the janitor varnished them to put on a high gloss finish because the factory, he thought, "has not been doing a good job of finishing since the war."

Some of these errors were not discovered until the Fall term started. A responsive school board is correcting them as quickly as possible. Venetian blinds are being added to the vision strip. One room has been decorated in accordance with the original recommendations. A photometric test of this room has been made and found to meet all requirements of the American Standard Practice for School Lighting with the exception of the sky-brightness through the vision strip and a slightly out-of-balance dark floor. On a test day sky-brightness through the unshielded vision strip was as high as 3450 footlamberts, a ratio of 38 to 1.

From a lighting point of view, the dark lockers at the back of the room robbed the students in that section of 9 footcandles of illumination.

Only 75 Per Cent Good When Schools Started

If we were to "grade" this school as a term paper, at the time of completion these classrooms would have rated 75 per cent, just passing. By the time the room was redecorated and venetian blinds added to the vision strip, the photometric "grade" was about 92 per cent. If we had not planned for a 100 per cent perfection in these classrooms, we'd never have got it up to 92 per cent, because of unalterable fundamental errors in design or construction.

Luckily, prismatic glass block, green chalk boards, luminous indirect fluorescent equipment, and natural-finish desks were part of the original plans which were carried out. But any one of these might have been overlooked due to a misunderstanding as to their purpose. Even though the school superintendent, the school architect and the school board are convinced as to what makes a co-ordinated classroom, in the natural competitive system in which bids are let and subcontracts issued, there is bound to be attempted savings or short-cuttings which will cross-up any well designed plan, unless it is policed constantly. In lighting, for example, the chain of sale from the school board to the general contractor, to the sub-contractor, to the electrical contractor, to the electrical wholesaler, and finally to the manufacturer is so long and involved that constant check is required to assure a child the square deal in school environment which the school people intended and planned to give him.

"Why plan for such perfection?" If it were possible, we should plan even *beyond* perfection, then supervise constantly in order to get something better than three-quarters of what was planned, accepted and authorized originally.

High Grade Lighting for High Priced Man Hours

By ARTHUR A. BRAINERD

IN A LARGE factory I visited recently—a lighting equipment manufacturer famed for its enthusiasm for quality lighting—the office lighting was ideal. Back in the production area, however, the quality of the lighting was hopelessly poor, by any standard of comparison. To be sure, the equipment was of a standard design for industrial work, but the ceiling was dark. Direct and reflected glare were present, and the illumination was fully 75 per cent below I.E.S. standards.

This incident is not uncommon. In fact, it is so common that we might almost call it standard practice. We do provide a better grade of illumination for a $60.00 week stenographer than we provide for

In an age when more and more attention is being paid to lighting and decorating all kinds of interiors, we are not providing the best seeing conditions for the areas where things are being made. So far as quality of lighting equipment is concerned, the requirements for a production area are fully as stringent as for offices. With an ever-rising standard of living, decoration is no longer a luxury. Good decoration in a factory is a definite contribution to accurate, rapid and comfortable seeing. American industry deserves the best in lighting.

MR. BRAINERD is an illuminating engineer with the Philadelphia Electric Co., Market Studies and Service Division, Philadelphia, Pa.

Figure 1. Harmonious light colored surroundings and well planned illumination, ease the work in the inspection process.

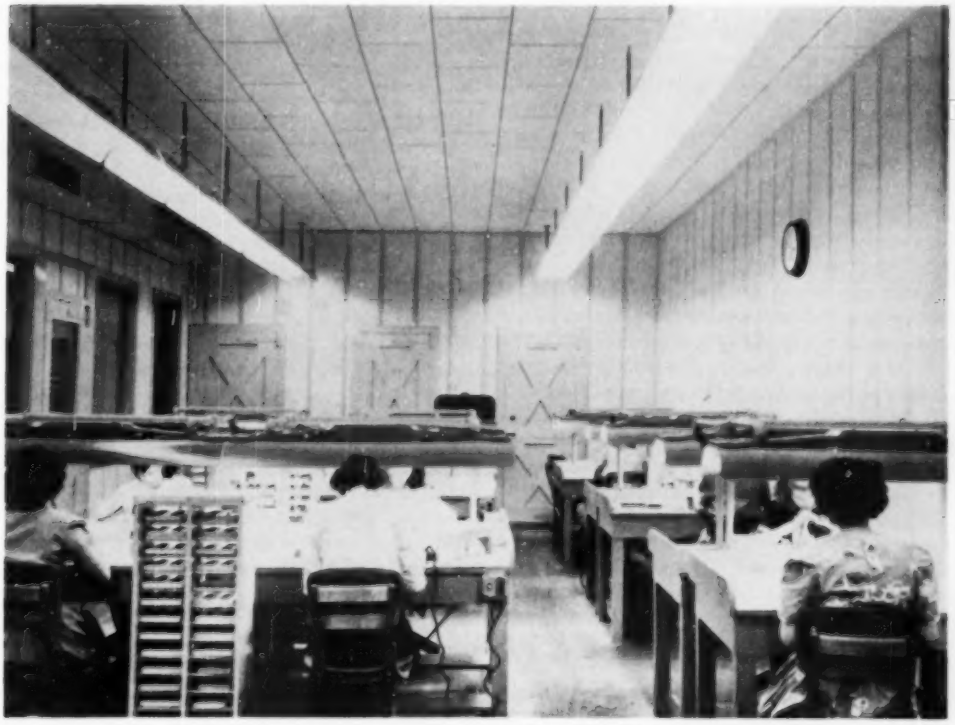


Figure 2. Light colored contrasting surfaces and high level diffuse lighting reduce fatigue in this machine shop.

a $3.00 or $4.00 an hour skilled mechanic. Why?

We do not know too much about glare, and as yet no satisfactory system of measurement has been discovered. Nevertheless, it should be self-evident that a piece of lighting equipment that is glaring in an office will be equally uncomfortable in a factory. The present wide spread practice of finishing machines in light contrasting colors indicates that the glare existing in most factory lighting installations is recognized.

Under pressure of wartime necessity, we learned many things about increasing the efficiency of the human machine. Planned rest periods, handy refreshment stands, appropriate music, machines painted in contrasting colors, air conditioning — and many others. Along with these considerations there occurred a complete reappraisal of the quantity of illumination necessary for efficient 24-hour per day production. Fifty footcandles was commonly used where 15 footcandles had formerly been considered adequate. But the old double standard of quality remained, and the office still experienced better illumination than the production areas.

Unquestionably many manufacturing operations could be carried on to a better advantage with high quality diffusing equipment of the type that is used in offices. Many authentic cases are on record where luminous indirect or totally indirect lighting have shown a definite increase in production.

Two reasons have been advanced as to why the practice of using high quality equipment is not more generally recommended and adopted for production areas — initial cost, and labor and cost of cleaning. It is apparently common practice to call bad lighting good for the ridiculous reason that this is the only kind of lighting that fits an arbitrary budget. There is no logical reason, budget included, why the skilled mechanic at the bench or on the production line shouldn't have as comfortable and efficient indoor working conditions as the draftsman or stenographer. Indeed, the workman's services frequently cost considerably more per hour than the office worker's. Surely an equal investment in their seeing environment is warranted.

Most of us spend most of our daylight hours indoors, under conditions which demand the use of artificial light 100 per cent of the time. Moreover these indoor hours in the daytime are the hours when we do our creative work. For this reason alone it is a natural assumption that no effort should be spared to make this indoor environment compare favorably with the best natural out of door conditions. We have long since learned by experience that we cannot hope to accomplish any such result by the simple process of piling the floor knee deep in footcandles.

In creating a satisfactory indoor environment, every object in the room should be studied from the standpoint of continuous general comfort as well as for easy accurate seeing. Machine tool manufacturers have done much to streamline their products so that they are pleasing to the eye as well as efficient. Outstanding improvements have been made in the methods of painting these machines, as well as the walls and ceiling. In spite of all this improvement, however, lighting equipment that is glaring and far from pleasing to the eye, is frequently used. Lighting from direct reflectors is called good by most lighting engineers, but just being good is not enough. Modern manufacturing conditions demand the best if we are to secure the highest reasonably attainable standard in quality and quantity of work, and with a minimum of fatigue on the part of the workers. The environment of a factory room lighted with open direct type of equipment does not compare favorably with the best outdoor conditions — and it should.

Basic Seeing Requirements

For many years the Illuminating Engineering Society has from time to time published tables of recommended illumination levels. These tables de-

scribe definitely the quantity of light recommended for any specific seeing task. However, until recently the description of quality of light desired was quite general. Within the last four years, the description of quality has been more definite as our knowledge of quality measurements has been extended.

As long as we were confined to the use of concentrated light sources it was hardly practical to achieve over 30 or 35 footcandles without glare and discomfort. The general adoption of low brilliancy, high efficiency extended light sources within the past ten years has enabled us to secure light in far greater quantities economically. To be sure, these lamps are much lower in intrinsic brightness than the filament lamp. However, at current lighting levels, glare is often present — even though it is harder to identify and measure. Much has been accomplished by specifying the brightness distribution of the luminaire, and the brightness ratio between the luminaire and its surroundings.

The rules that we now have are largely empirical, but they do reduce the rating of a lighting installation to a system. The matter of far greater precision and accuracy is something which will correct itself in the normal course of research and development. However, the matter of a double standard of quality for the lighting of visual tasks of comparable severity is hard to explain. There is pretty general acceptance of 50 footcandles as a desired level for both offices and factories. But there the logic ends. The standard type of industrial luminaire is still the porcelain enamel reflector with two or three bare fluorescent lamps. Rarely is a compromise with quality made by equipping the reflectors with eggcrate louvers. Even when it is, no light goes to the ceiling to relieve the depressing effect of relative darkness. In offices, however, the much cherished flush troffer type of luminaire is now gradually giving way to the all luminous ceiling of the louverall, luminous plastic or glass type. If this type of lighting is needed for the best seeing in offices, it is also needed in the production areas. We need quality as well as footcandles where things are being made.

When the seeing task is such that shadowless illumination is required it should be secured in the same manner that illumination of a similar quality is produced in an office.

Our present standard of quality of lighting is the result of a natural process of evolution. Twenty-five years ago 200-watt RLM's on 10-foot centers was considered the last thing in industrial lighting. A luminaire cost around $2.50. Now we install 100-watt fluorescent units producing 50 per cent more light, in continuous lines from one end of the factory to the other. These cost about $15.00 or $20.00 each. Our idea of a reasonable cost of good lighting for an industrial lighting installation has increased several hundred per cent, and this increase has proved to be a paying investment.

The real problem centers in the fact that even if good diffusing equipment is installed, the seeing conditions are not automatically improved unless the whole interior is treated for effective light utilization. The practice of painting machines and benches in contrasting colors of high reflectance is no longer a novelty. It is standard practice in a large percentage of well organized industrial plants. Sometimes the trouble lies in the presence of a multitude of overhead obstructions which tend to discourage any attempt to make the working area comfortable to the eye. Steam lines, air lines, gas lines, sprinkler heads and a multitude of other services can be rearranged or camouflaged so that they do not become perpetual eyesores. Overhead shafting, of course has no place in a modern production area.

To accomplish a factory environment comparable with that in offices may mean a major redesign of buildings. Certainly there is nothing impractical in using an all-luminous ceiling for a busy production area. There is no objection to having a color scheme on machines and walls and ceilings that will produce the best brightness and seeing conditions. Who is to say that we should not employ skilled interior decorators in the factories of the future? The wealth of America comes in no small degree from our production lines. The workers who make things spend most of their daylight hours indoors. Anything that we can do to make this indoor environment more comfortable should be done.

Maintenance

Of course, the initial cost is not the whole story. Lamps must be renewed, luminaires cleaned, and paint washed or renewed. Even with the best housecleaning, a depreciation of 50 per cent in six months is the rule rather than the exception. Moreover, with lamps now on the market, a life of 10,000 hours is not uncommon — giving 150 per cent more time to collect dirt before it fails.

The control of depreciation is a perplexing engineering problem. It costs more to paint at three-year intervals than at nine years. It costs money to clean lamps that last 10,000 hours. The result, however, can easily be a 100 per cent increase in usable illumination with the same equipment. And although difficult of accurate measurement, the effect on human efficiency is very great.

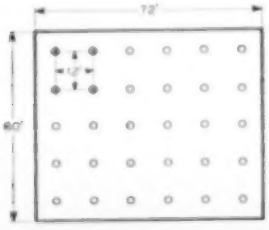
Planned Lighting in Industry Is Production Lighting!

By BENJAMIN S. BENSON, JR.

Problem No. 1

Industrial area—Storage of miscellaneous equipment
Dimensions—60 feet wide by 72 feet long
Mounting height of lighting units—12 feet above floor
Reflection factor—Ceiling 75 per cent; Walls 50 per cent
Illumination desired—approximately 10 footcandles (average maintained)

Solution: Lighting System 1
Lighting units—RLM domes
Lamps—200 watt incandescent
Maintenance factor—65 per cent
Quantity of lighting units—30
Calculated horizontal illumination—11 footcandles maintained
Approximate footcandles per watt per square foot—7.9



NOWHERE else in the world but in these United States is a nation's economy geared so closely to its industrial production.

In the space of a relatively few years tremendous advances have been made in the mechanical field. A product that once required hours to fashion by hand can now be made in minutes. Where production once was measured in units per day it is now measured in thousands of units per day.

Man—on the other hand—is pretty much the same sort of animal he was many hundreds of years ago. He still has only two feet, two hands, two eyes. While modern machinery has made it possible for one pair of hands to do the work of ten, it has had no such success in increasing the amount of work done by the eye.

A vital link between the mechanical element and the human element in industry is lighting. Good

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Typical lighted appearance of a similar solution.

lighting can, in effect, increase the amount of work done by the eye. Proper Lighting — Production Lighting — Planned Lighting — is an important tool in today's industrial plant. A tool whose advantages are many — whose neglect is costly.

It requires time to see. The eye — like a camera — needs a longer exposure for a good picture under low levels of illumination. Increased illumination means increased speed of vision. Time saved in seeing permits increased production. Planned Lighting can help increase production.

With good lighting the worker can *see* rather than *guess* what he is doing. Fewer mistakes are made and these more readily detected. Earlier re-

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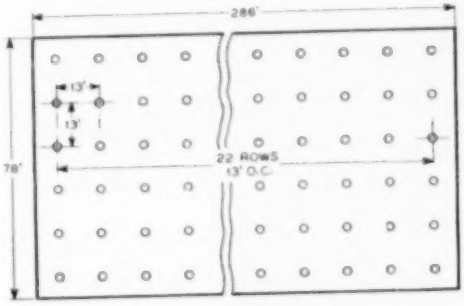
Problem No. 2

Industrial area—Machinery and assembly of heavy equipment
Dimensions—78 feet wide by 286 feet long
Mounting height of lighting units—40 feet above floor
Reflection factors—Ceiling 50 per cent; Walls 10 per cent (including windows)
Illumination desired—50 footcandles (average maintained)

Solution: Lighting System 3
Lighting units—Enclosed aluminum
Lamps—1000 watt incandescent
Maintenance factor—70 per cent
Quantity of lighting units—132
Calculated horizontal illumination—50 footcandles maintained
Approximate footcandles per watt per square foot—8.5



Typical lighted appearance of a similar solution.

jection saves time and cost. Experience indicates that good lighting can lower the spoilage rate by 50 per cent. Planned Lighting can help increase quality.

A downed employee and his idle machine are a non-profit combination in industry. Many times accidents that are saddled upon the carelessness of the individual are, in truth, due to improper lighting. Proper quality and quantity of illumination aid in reducing accidents. Planned Lighting can help increase safety.

Tired eyes are inefficient eyes — are dangerous eyes — in industry. Seeing consumes energy on the part of the worker. Under poor lighting conditions the task of seeing can have considerable effect upon the nervous and muscular system. An employee

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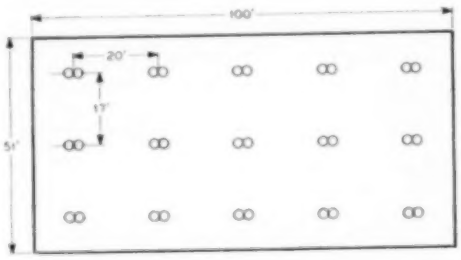
Problem No. 3

Industrial area—Fabrication and partial assembly of heavy steel members
Dimensions—51 feet wide by 100 feet long
Mounting height of lighting units—26 feet
Reflection factors—Ceiling 30 per cent; Walls 10 per cent
Illumination desired—30 footcandles (average maintained)

Solution: Lighting System 3

Lighting units—Tandem mounted enclosed aluminum for combination mercury incandescent lighting
Lamps—400-watt ATH 1 mercury, 750-watt incandescent
Maintenance factor—65 per cent
Quantity of lighting units—15 tandem assemblies
Calculated horizontal illumination—33 footcandles maintained
Approximate footcandles per watt per square foot—9.4



Typical lighted appearance of a similar solution.

suffering from eyestrain and fatigue is less apt to be a careful and safety-conscious employee. Planned Lighting can help reduce fatigue and eyestrain.

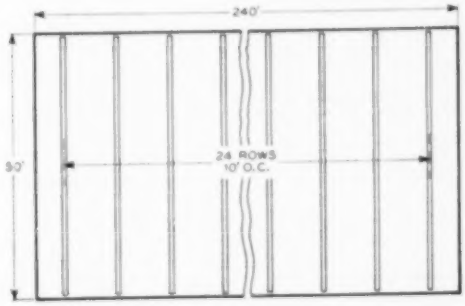
A general lighting plan providing a satisfactory level of uniform illumination throughout a factory area permits machine arrangement for most efficient production. Machinery and production methods can be changed at will without change in the lighting. Planned Lighting can help increase the utilization of the floor space.

The lighting "atmosphere" should vary with the task. Low level illumination provides the right "atmosphere" for romance. Move the couple out and a lathe and operator in and it's all wrong! The machine is geared for production — the lighting for romance. The solution—change the "mood"

Problem No. 4

Industrial area—Shearing and temporary storage
Dimensions—50 feet wide by 240 feet long
Mounting height of lighting units—25 feet above floor
Reflection factors—Ceiling 50 per cent; Walls 10 per cent (including windows)
Illumination desired—30 footcandles (average maintained)

Solution: Lighting System 8
Lighting units—2-lamp industrial RLM fluorescent (continuous rows)
Lamps—40 watt, T 12, 4500° white fluorescent
Maintenance factor—65 per cent
Quantity of lighting units—264
Calculated horizontal illumination—30 footcandles maintained
Approximate footcandles per watt per square foot—13.6



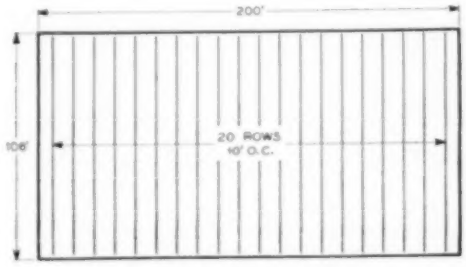
Typical lighted appearance of a similar solution.

lighting. The cheerful appearance of a well lighted area helps to put the worker in a happy frame of mind. A happy worker is a better worker! Planned Lighting can help improve morale.

Planned Lighting in Industry involves the proper correlation of quantity and quality of illumination to the task to be performed and these, in many cases, balanced against economic factors. The amount of light reaching the task is, in itself, not the entire answer to a satisfactory lighting solution. Such elements should also be considered as glare (both direct and reflected), brightness ratios, spectral characteristics of light desired, power supply (direct or alternating current), frequency of current interruptions, maintenance, investment, cost of power and lamp replacements.

Problem No. 5
Industrial area—Tool manufacturing
Dimensions—106 feet wide by 200 feet long
Mounting height of lighting units—11 feet above floor
Reflection factors—Ceiling 75 per cent; Walls 10 per cent (including windows)
Illumination desired—50 footcandles (average maintained)

Solution:
Lighting units—2 lamp industrial fluorescent (continuous rows)
Lamps—40 watt, T-12, 3500° white fluorescent
Maintenance factor—65 per cent
Quantity of lighting units—520
Calculated horizontal illumination—50 footcandles maintained
Approximate footcandles per watt per square foot—19.0



Typical lighted appearance of a similar solution.

The I.E.S. Committee on Industrial Lighting as well as the Committee on Lighting Study Projects in Industry through its numerous important subcommittees, are constantly studying the lighting requirements of many types of industry with the aim of ever broadening the Society's knowledge of industrial lighting.

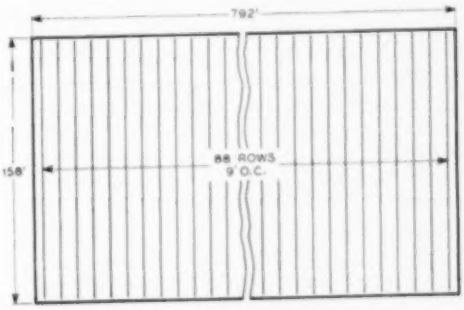
There are available, for the convenience of the user, several methods of classifying types of industrial lighting units according to use. These are intended primarily as guides and are, of necessity, broad in interpretation. Because of space limitations many types of lighting units are necessarily omitted. The system purports to show the more commonly encountered tasks and the more usual types of lighting units for their general illumination.

Problem No. 6

Industrial area—Automobile assembly line
Dimensions—158 feet wide by 792 feet long
Mounting height of lighting units—10 feet above floor
Reflection factors—Ceiling 75 per cent; Walls 30 per cent
Illumination desired—50 (plus) footcandles (average maintained)

Solution: Lighting System 8

Lighting units—2 lamp industrial RLM fluorescent (continuous rows)
Lamps—75 watt, T 12, 3500° white fluorescent
Maintenance factor—65 per cent
Quantity of lighting units—1,672
Calculated horizontal illumination—60 footcandles maintained
Approximate footcandles per watt per square foot—23.4



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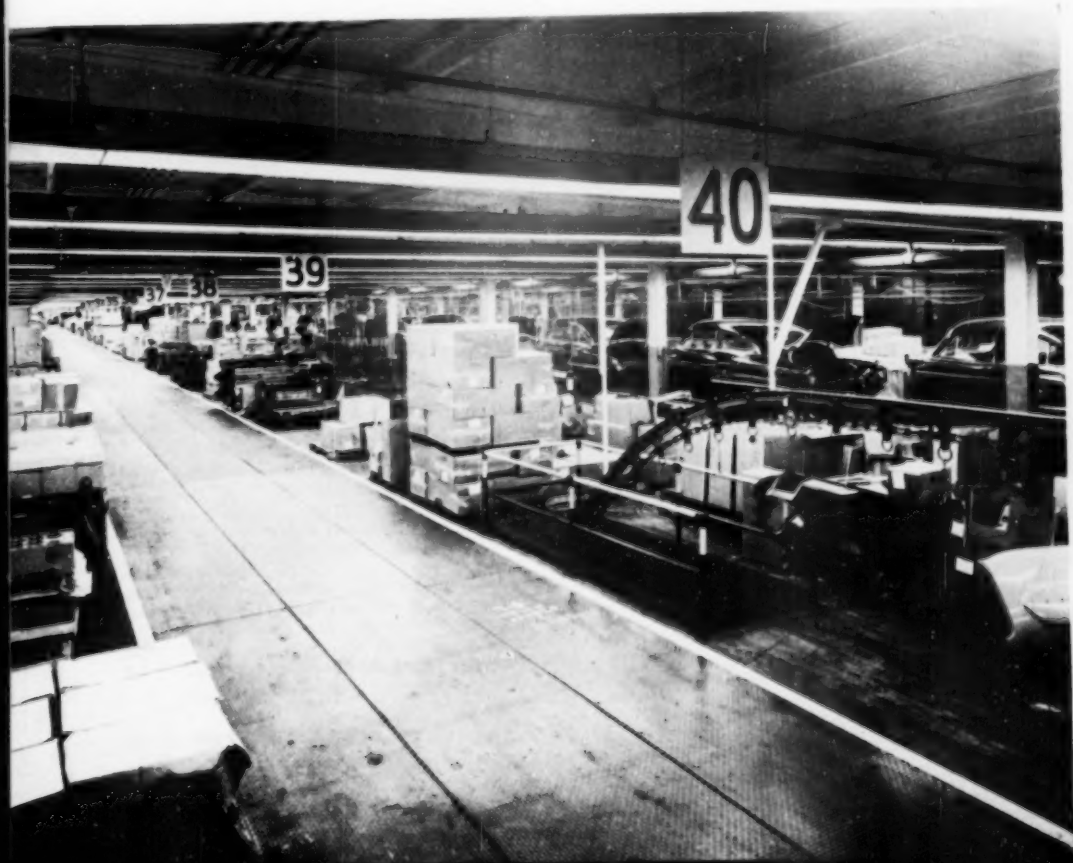

Luminous Ceilings

By J. F. PARSONS

A LUMINOUS ceiling is a form of direct lighting in which the entire ceiling surface or a large continuous portion of it becomes the visible light source.

Ceilings may be made luminous in two ways: by reflectance and by transmittance. With the former method the ceiling is usually painted flat white, and light projected on it from below by pendant luminaires or other means. This is the familiar indirect lighting which is "indirect" only from the luminaire's point of view; from the view of the observer the effect is that of direct lighting from a luminous ceiling.

Where transmittance is used the suspended ceiling of the room is of a translucent material above which are the light sources which provide the illumination. The lamps are hidden from view by the diffusing ceiling and this surface is the visible source of light.

New light sources and diffusing materials of which the suspended luminous ceiling is fashioned have recently revived interest in this form of lighting, which is actually one of the oldest methods known of introducing illumination, whether natural or artificial, into the interior. The temples of the ancient world and the patio of medieval times, both open to a uniformly bright sky on an overcast day, provide visually the same result as a luminous ceiling. Many art galleries and auditoriums have large horizontal glass areas covering practically the entire ceiling surface with glazed penthouses above to keep out the weather, supplemented by incandescent lamps in reflectors suitably spaced to provide even illumination of the translucent ceiling surface.

Luminous ceilings in their present-day applications produce about the same results as indirect lighting from suspended luminaires. The light source is large and so may be of relatively low uniform brightness to produce a given level of illumination with minimum direct and reflected glare.

A charge has been brought against indirect lighting, and consequently will also arise in connection with luminous ceilings, as it has been shown they are closely allied. This is to the effect that with indirect lighting the ceiling in large rooms becomes too bright for comfort at lighting levels in the vicinity of 50 footcandles. Evidence has been presented that this point of view has been somewhat exaggerated. Report No. 4* of the Committee on Standards for Quality and Quantity of Interior Illumination shows that in indirectly lighted large rooms, brightness ratios which might have resulted in discomfort at higher levels were brought to nearly optimum value by changing the reflectance of the floor from 0.10 to 0.30. Consequently with luminous ceilings this detail should receive special attention.

Another possible reason for discomfort in indirectly lighted large rooms at higher illumination levels is the practice of using high output luminaires hung close to the ceiling surface, resulting in "hot spots" directly over the luminaires and producing brightness ratios over the ceiling surface beyond the comfort level which become more critical as higher ceiling brightnesses are encountered. This

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* "Brightness Distribution in Rooms," ILLUMINATING ENGINEERING, Vol. XLII, No. 2, p. 180 (February, 1947).

Figure 1. Luminous ceiling in private office: 12 ft x 13 ft; 12 ft to luminous ceiling. Eighteen 48-inch T-12 425 ma, 3500K lamps are used in 6 rows of 3 lamps, 36 inches above the corrugated plastic sheeting diffuser. Watts per square foot, 5.1. Illumination on the horizontal work plane is 48 footcandles; brightness of ceiling is 132 footlamberts after two months operation.

condition may, of course, be corrected by using a larger number of luminaires of lower output and a greater suspension distance.

With a properly designed luminous ceiling as with a well-planned indirect lighting system, taking into account not only the lighting equipment but the reflectances and textures of the environment, it appears feasible to create comfortable, effective seeing conditions at general lighting levels encountered in current good practice. Brightness ratios within the 3 to 1 criterion are easily obtained with all but the most unfavorable room proportions.

The close relationship between the luminous ceiling and indirect lighting brings to mind an economic comparison. Limited data on luminous ceilings indicate that their first cost has varied from $4.00 to over $7.00 per square foot. Indirect lighting can usually be installed for half of the lower figure or less. If a suspended ceiling must be installed for the indirect lighting its cost, perhaps 70 cents per square foot, may be legitimately deducted from the cost of the luminous ceiling.

Techniques for effective acoustic treatment of areas with luminous ceilings are under consideration but no extensive report has been made.

Maintenance

The depreciation of illumination from a luminous ceiling depends on a number of factors. Unless the ceiling and the cavity are fairly tight, dust will accumulate. Even with tight construction a certain amount of breathing will take place which will introduce dirt. Dust on the upper surface of the plastic not only causes absorption but reduces the reflectance of the diffuser, which is an important factor in the ouput efficiency of the luminous ceiling. Depreciation of the reflectance of the cavity and of the lamps causes further reductions. The maintenance problems involved should be realistically faced before selecting this lighting method. Proper scheduling of washing the diffuser panels and of repainting the cavity is essential. Group replacement of lamps can often be economically justified. Some types of plastic tend to collect dust electrostatically. This can be minimized by waxing the panels or by washing them in a detergent and air-drying without rinsing.

Design

Either glass or plastic of proper optical characteristics may be used as the suspended ceiling. This material is laid in a hung frame of T-bars or similar construction, in sheets of a size which make for convenient handling or in accordance with the manufacturer's recommendation for clearances and maximum unsupported span. The cavity above should be of sufficient depth to obtain the proper relation between spacing of lamps and vertical distance from the diffuser to produce uniform brightness of the luminous ceiling. This space above the diffuser should be relatively unobstructed and its entire surface and contents, if any, painted gloss white. It should preferably be no deeper than necessary to provide the proper spacial relationship. The diffusing material should combine high transmittance and reflectance. The former alone is not enough to insure maximum efficiency as good reflectance of the diffuser causes the light to bounce around repeatedly within the cavity and thus affords it a better chance of ultimate escape. Thus a diffuser with a transmittance of 0.50 and a high reflectance may have an output efficiency of 0.75 when used in a luminous ceiling with a properly designed cavity. When fluorescent lamps are used they may be run in continuous rows on a single wiring strip without reflectors, the strip preferably mounted on the upper surface of the cavity. If a plastic diffuser is used it may be flat or corrugated for stiffness. It may in some instances be desirable to de-polish the bottom surface to avoid reflections.

A typical arrangement is one in which the cavity is 15 inches deep, the distance of lamps from the

Figure 2. Luminous ceiling in a school room. Dimensions are 33.5 ft x 25 ft; height to ceiling 10 ft 6 inches. Twenty-eight 96-inch T-12 425 ma, 4500K lamps are used in 7 rows of 4 lamps each, 22 inches above a corrugated plastic sheeting. Illumination on horizontal work plane is 65 footcandles; brightness of ceiling is 88 footlamberts, after three months operation. Watts per square foot, 2.9. Photo courtesy Martin Electric Products Inc., Somerville, Mass.

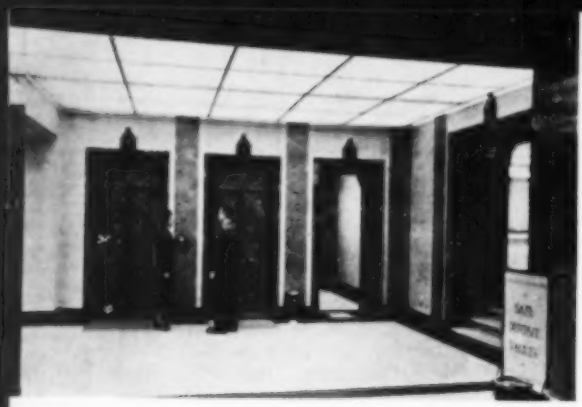


Figure 3. Luminous ceiling in elevator lobby: 13 ft x 20 ft; 10 ft to luminous ceiling. Twenty 72-inch, T-8, 200 ma lamps are used in rows 2 ft on centers above a diffuser of one-eighth inch corrugated plastic in 4-foot square panels. Watts per square foot 4.2. Photo courtesy Rohm & Haas, Philadelphia, Pa.

diffuser is 12 inches, spacing between the rows of lamps is 24 inches. The diffuser consists of 24-inch squares of $\frac{1}{8}$-inch plastic mounted on $1\frac{3}{4}$-inch T-bar frames. The spacing of the lamps should not exceed twice the mounting height above the diffuser. The entire cavity is finished in gloss white of 0.80 reflectance. For uniform brightness the lamps are spaced closer at the sides of the cavity and ends are carried somewhat past the end of the diffuser.

Calculating the number of lamps required to produce a given illumination level in service is handicapped to some extent by lack of basic information in familiar, usable form on coefficient of utilization and maintenance factors. Basic investigation is needed to determine the relations between the various design factors such as dimensions of room, depth of cavity, lamp spacing, and transmittance and reflectance of the diffuser. Readily usable data in form similar to the familiar utilization tables should be made available. Realistic maintenance

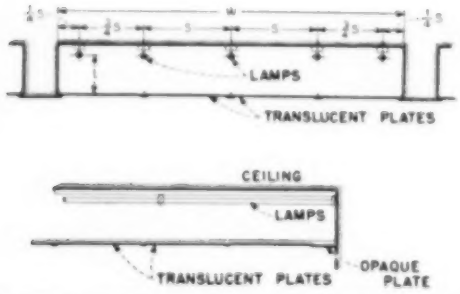


Figure 4.* Sections of a portion of a luminous ceiling showing spacial relationships. The distance S should not exceed 2*l*.

*From "Luminous Ceiling Lighting" by Parry Moon and D. E. Spencer, ILLUMINATING ENGINEERING, p. 470 (August, 1949).

factors should also be determined. In the meantime, calculations may be made which are in reasonable agreement with illumination measurements made of actual installations, using the interreflection method.

To make such calculations it is first necessary to determine the required average initial ceiling brightness to produce the design illumination in service. This is calculated from the formula:

$$\text{Initial Brightness of Ceiling} = \frac{\text{Ft-c in Service} \times \text{Factor from Table I}}{\text{Maintenance Factor}} \qquad (1)$$

To use Table I it is first necessary to determine the Room Coefficient which is similar to the familiar Room Index using the formula:

$$\text{Room Coefficient} = \frac{\text{Ceiling Ht} \times (\text{Length of Room} + \text{Width})}{2 \times \text{Length} \times \text{Width}}$$

TABLE I.—For Rooms with .50 Wall Reflectance, .30 Floor Reflectance.

Room Coefficient	Factor
0.1	1.11
0.2	1.23
0.3	1.36
0.4	1.51
0.5	1.68
0.7	2.08
1.0	2.86

A high degree of accuracy in determining utilization of the light is futile so long as valid maintenance factors are lacking. Based on published data for other types of luminaires and on actual experience in the field it is suggested that for purposes of calculation a Maintenance Factor of .50 for "Good" and .40 for "Medium" conditions be assumed. Where maintenance conditions are "Poor" it will be well to consider some other lighting method.

Having determined the average initial ceiling brightness required from (1), the number of lamp lumens necessary to produce it is determined from the formula:

$$\text{Total Lamp Lumens Required} = \frac{\text{Brightness of Ceiling} \times \text{Area of Ceiling}}{\text{Output Efficiency of Ceiling as a Luminaire}}$$

The efficiency will vary depending on the properties of the diffuser and the cavity but a study of existing data indicates that .65 is a reasonable average figure.

A typical example follows:

Room 34' x 25' with luminous ceiling 10 feet above floor. 50 footcandles in service is required

(Continued on page 324)

Basic Fundamentals Answer to Supplementary Lighting Problems

By W. H. KAHLER

The illuminating engineer is often called upon to recommend ways and means of improving visibility of a specific seeing problem. These specific seeing problems may be solved by the application of the correct quantity and quality of general illumination but in most cases they involve the application of lighting equipment that will supplement the general lighting system.

APPLICATIONS for supplementary lighting are found in practically all branches of interior lighting but the most numerous and most frequent problems are found in industry.

To improve the visibility of a particular seeing task it is first essential to recognize the task and to understand its light reflecting (or transmitting) characteristics. The seeing task is usually a certain detail that must be visually resolved in the midst of a more or less complex visual field.

By knowing how the task is actually seen it is possible to determine why the task is difficult to see. Here one can directly apply the four fundamental factors of vision: (1) Brightness, (2) Contrast, (3) Size, (4) Time.

These four factors can only be considered separately in an academic discussion because in practice their inter-dependence is basic and vision is impossible in the absence of any one. No single factor is most important in all seeing tasks but we may often single out the factor that is easiest to control with a given set of conditions. Thus in analyzing the problem the illuminating engineer may ask:

1. What is the actual seeing task?
2. Why is it difficult to see?
   a. Is it lack of brightness?
   b. Is it poor contrast?
   c. Is the size too small?
   d. Is there insufficient time to see?

The true stimulus to vision is the brightness intercepted by the retina of the eye. The brightness of the task is the candlepower directed in the direction of the eye from the detail and its background.

Tasks with a diffuse surface, such as non-glossy paper or flat paint, will reflect light in all directions. The brightness is therefore a function of footcandles and the diffuse reflection factor. The brightness of the source has practically no effect on the reflected brightness of a diffuse surface.

Specular surfaces, such as polished metal or a glass mirror, reflect light at an angle equal to the angle of incidence. The brightness of the surface depends upon the angle of view, the specular reflection factor, and the brightness of whatever is reflected at the corresponding angle of incidence.

Brightness alone, however, does not produce visibility. A condition of contrast must be established before perception of detail is possible. Contrast may be a difference in brightness, a difference in color or a combination of both.

Figure 1. Contrast by High Brightness Reflection. In coal picking, the "inspection line" of the coal industry, slate, copper stone, bone coal and other impurities must be separated from the good coal. High brightness sources (400 Watt Mercury) in well shielded dust-tight luminaires give the coal a "sparkling" appearance in contrast to the dull impurities.

MR. KAHLER is with the Westinghouse Electric Corp., Cleveland, Ohio.

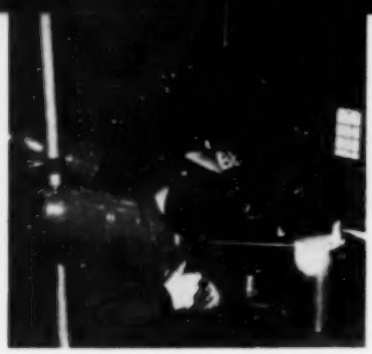


Figure 2 (Left). Contrast by Low Brightness Reflection. This indirectly illuminated light hood serves two purposes essential to better visibility. The low brightness and large area characteristic provide excellent visibility of verniers because scale markings have good contrast against the luminous reflected image of the source. The hood is large enough to shield out direct brightness of skylights and fluorescent lamps and thus prevent reflected glare. Figure 3 (Center). High Brightness Compensates for Poor Visibility Condition. Two 45-watt, 6-volt PAR-46 reflector spot lamps provide approximately 6,000 footcandles at the point of work to compensate for low transmission of weld lens and poor task contrast. The welder with a foot-switch control can see his work before striking the arc without raising his hood. Figure 4 (Right). Brightness Contrast on Specular Surface. For tasks of limited area a small shielded source can be located to produce brightness contrast of scribe lines on a block of specular steel. In the case illustrated the luminaire is adjusted so that scribe lines reflect source brightness toward the eye, but surface of block reflects source brightness away from the line of sight. Thus, the block appears darker than lines.

High contrast, as black on white, gives maximum visibility and therefore with seeing tasks of poor contrast every possible means for improving this contrast should be investigated.

Often, however, contrast of the task can not be altered and the solution must be found by some application of light. In the case of non-specular detail and background, poor contrast can be compensated by higher illumination levels. For example, we may compare two similar tasks such as black print on white paper and black print on gray paper (reflection factor 20 per cent). If 10 footcandles is considered satisfactory for the first case with good contrast, 50 footcandles will be required to produce the same visibility on the task of lesser contrast.

Industrial operations frequently involve tasks of poor contrast and with specular surfaces. A low brightness source is particularly useful for such applications. When the detail is an actual break in the specular surface such as a scratch or engraving cuts, illumination can be provided by a source of moderate brightness and usually vision is best when the surface and source are oriented so that details appear bright against a dark background. When it is not practical to orient the surface or source, a low brightness source of large area should be used; large enough to produce a luminous background against which the details can be seen.

Irregularities that do not break a specular surface, such as dents or warps, are seen best when the surface reflects an image of a low brightness uniform source with a pattern. The pattern may be produced by opaque stripes on a low brightness luminous panel or may be the frame or edge of luminaires mounted adjacent to each other. Any irregularity in a surface so illuminated will cause a distortion of the reflected image of this pattern.

In addition to differences in reflection factor, contrast may be created by different colors, by shadows and silhouettes, and by such special effects as fluorescence and polarization.

Figure 5. Contrast by Fluorescence. Minute surface flaws in metal and non-porous plastic and ceramic parts can be easily detected by the use of fluorescent materials and black light. In illustration (A) (below) the casting appears to be perfect under visible light. In (B) (facing page) black light and fluorescent materials cause the cracks to glow in distinct contrast against the dark background.

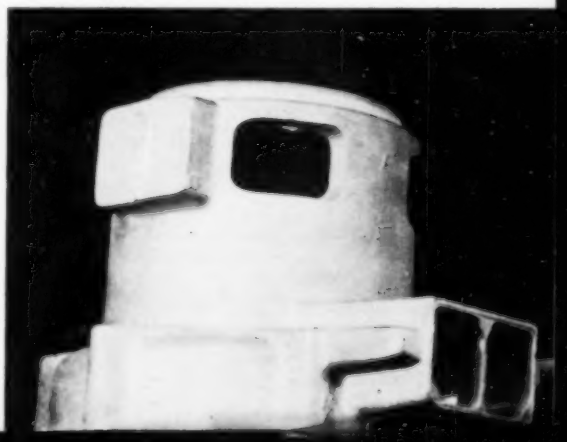
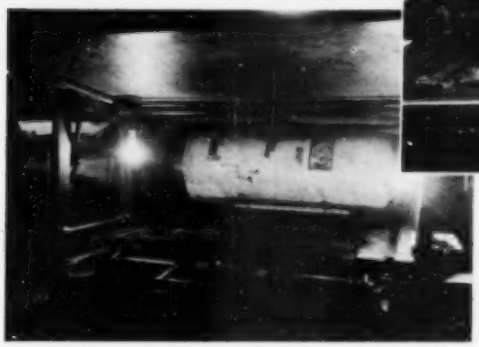
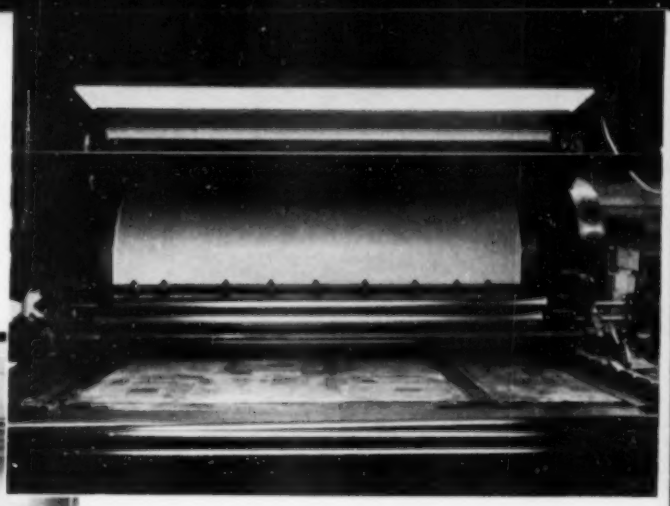


Figure 6. Comfort. Both visual and physical are important considerations in planning supplementary lighting. "A"—The lighting for the bed of this printing press, as found, consisted of two 200-watt incandescent lamps that caused very annoying glare and heat. "B"—Both faults were corrected by using two single lamp, 40-watt fluorescent luminaires with deep reflectors. Note that one reflector is mounted level and the other is tilted inward to better illuminate the cylinder.





Color, as part of the seeing task for a specific color quality of light, can be very effectively used to improve contrast.

The color of light can be used to increase contrast by either intensifying or subduing certain colors inherent in the seeing task. To intensify a color the light source should be strong in this color and to subdue a color the source should have relatively low output in the particular color. For example, it has been found that chromium plating imperfections over nickel plating can be emphasized by using a bluish color of light such as the daylight fluorescent lamp. It has also been found that the color quality from green fluorescent lamps increases the contrast of rust on metal making the rust easier to see.

Most three dimensional objects are seen in their apparent shape because of the shadows and highlights resulting from certain directional components of light. The directional effect is particularly useful in emphasizing texture and defects on uneven surfaces.

Silhouette is an effective means of showing contour. Silhouette letters on a sign and the matching of a template to a shape are examples of this technique for developing contrast.

Certain materials have the property of fluorescing under ultraviolet radiation and this characteristic is often useful in creating contrast.

Polarized light can be used to develop a contrast condition in certain inspection operations. Stresses in glass can be detected by polarized light and plastic models of mechanical shapes will show the points of strain.

The visibility of an object of certain size depends upon the distance from the eye, the visibility becoming less as the distance increases. For equal visibility the size must be increased in direct proportion to the distance. An increase in brightness and brightness contrast can be used to compensate for small size.

The visibility of small detail can also be improved by the use of magnifying lenses. The combination of additional illumination plus a magnifier is a helpful seeing tool for the assembly or inspection of small visual tasks.

The time required to see a specific task is influenced within limits by size, contrast and brightness. A task of large size, of high brightness and with high brightness contrast can be seen most rapidly. Often brightness can be increased so that the task may be seen more accurately within a limited time. The possibility of increasing contrast should never be overlooked, for high contrast is a very important contributor to minimizing the time to see.

While high illumination levels lead to the maximum rate of vision, rapidly moving objects such as a rotating wheel generally cannot be seen in detail.

(*Continued on page 324*)

The Place of Louver Systems in Planned Lighting

By WENTWORTH M. POTTER

LOUVERS are shielding devices employed for brightness control to render a lighting installation comfortable to the eye. Built up into extended panels or wall-to-wall structures, they afford other desirable features. Outstanding among these is flexibility — in numbers and types of lamps employed, in the amount of light and its distribution throughout the area; in form and texture, and in the brightness and color pattern presented by the light-emitting elements with only small effect on the lighting result. Depreciation from dust and dirt is relatively low. They serve to hide unsightly ceiling elements, or, indeed, may themselves take the place of a finished ceiling. They give added scope to the architect and designer in the integration of lighting elements.

As usually applied, louvers permit the light from lamps, reflectors, or cavity above to emerge at the lower angles without modification, while controlling to the extent desired that emitted at the higher angles at which the system is ordinarily viewed. This is accomplished by choice of depth and proportions of the grid and the light-reflecting or transmitting properties of its elements. Because of the extended luminous area, such a system eliminates or greatly minimizes the problem of brightness contrasts with adjacent ceiling areas.

In determining when, where, and how extended louver systems should be used, one is concerned with architectural and structural considerations, with questions of present and future flexibility, with maintenance, with costs — initial and through life, and no less with a comparison of the lighting results achieved, quantitatively and qualitatively, as compared with those obtained by other techniques.

Individual luminaires or rows of them will usually supply lighting at lowest cost. They are available with a wide range of brightness and light-distribution control through use of louvers or translucent diffusing and redirecting materials. If on account of appearance considerations they are mounted close to the ceiling, there are limits to the amount of light falling on the ceiling and its distribution to relieve contrast with the luminaires, a limitation which can be overcome by suspending them below the ceiling and by proper redirection of the upward light. Once the installation is made it is relatively inflexible. The brightness of the luminaire itself is likely to be greater than in a system where the lamps can be distributed over a larger area, when high values of illumination are provided the number of luminaires and total bulk may become so large as to be unduly obtrusive.

In the recessed-troffer system reduction of brightness toward the eye is accentuated at the expense of contrast, that is, of light on the adjacent areas of the ceiling. At higher illumination levels the rows of troffers occupy a larger proportion of the ceiling area and more light is reflected to the ceiling from surfaces below, thus mitigating the problem. With etched aluminum troffers, endwise louvering, and relatively light non-specular surfaces throughout the room a high degree of quality and comfort is attained. If the task presents glossy surfaces the brightness of reflected images may be substantially reduced by using low-brightness lamps — and more equipment.

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Figure 1. Louverall over desk area, white wood cells, 12" x 12" x 12". Seventy-two 40-watt T12 lamps in 8 rows on ceiling channels 24" above grid. Illumination, 65 ft-c. Silver-bowl indirect filament luminaires in large coffers illuminate the circulation space. Adjustable spots for display table. Installation at the Kansas City Power and Light Co., Kansas City, Mo.

Figure 2. Louverall installation in the foyer of the Lamont Library, Harvard University, Cambridge, Massachusetts. Cells 3" x 3" x 3". Slimline fluorescent lamps on 18" centers, 120 milliamperes. Five 100-watt downlights above desk. Coolidge, Shepley, Bulfinch, and Abbott, Boston—Architect. Willard W. Thompson, Thompson Engineering Co., Boston, Consulting Engineer.

Brightness Control in a Louver System*

Louverall or louver panels enable one to deliver as much light as he may wish without impairing comfort, for they afford a much wider range of control so far as light entering the eye directly from the lighting system is concerned.

The requirements of visual comfort and concealment of surfaces above the grid determine the desirable shielding angle. For example, in general offices or school rooms with continued critical visual work, 45° is desirable. This angle is also preferred for concealment of unsightly objects, such as ducts, pipes, etc., above the grid. In a smaller room, a somewhat lower angle may suffice. In some stores the value of more light on vertical surfaces and higher over-all utilization may suggest shielding through only 30° or 35°.

The louvers themselves take on brightness, determined in amount by several factors. Brightness increases with reflectance or transmittance of the blades, with finishes that are glossy or of the "spread"-reflecting type, and with the number and light output of lamps above the grid. For example, the blade reflectance of 40° opaque louvers affects brightness and output as follows:

Blade reflectance	0.04	0.40	0.75	0.85
Relative average brightness at 25° below horizontal	0.08	0.36	1.00	1.25
Relative output	0.48	0.61	1.00	1.17

Brightness is reduced by greater grid area per lamp, by shielding through a greater angle, by the use of reflectors directing more of the light between blades. The latter technique alone can reduce brightness as much as 25-35 per cent for equal illumination. Nothing is gained by using dark cavity finishes; the resulting loss in output merely means that more lamps will have to be added to compensate, bringing the brightness of the louvers back to the same value.

For a given general footcandle level, a wall-to-wall grid obviously gives minimum brightness if the cavity is deep enough to mount the lamps well above the blades. Table I indicates average brightness for several louver systems and some other types of luminaires.

Comfort or glare rating is a function not of a luminaire or a panel but of the total installation and its environment. Number, distance, height of units, contrast with background, general brightness level, are all involved and their total effect may be approximated by the Harrison-Meaker method.* Subjective appraisals show that if the calculated glare factor does not exceed 15 the installation will be comfortable. With typical louver systems one is able to stay below 15 even at illumination values above 100 ft-c in a relatively large room.

The statement has been made that brightness ratios exceeding the desirable 3 to 1 limit are inherent in a louver system. This is not a fact at the usual angles of viewing, but applies when looking directly up into a unit. Whether or not the lighting system itself appears comfortable is important in every installation and all of the time. The incidence of glare from the straight-up view is quite another matter; in practice it enters chiefly to the extent that glossy surfaces occur in the illuminated area below.

Reflected Images and Highlights

Reflections of the lighting system from polished dark surfaces are the most troublesome. Their effect is less at higher levels of illumination, and is particularly minimized in the case of light-toned surfaces. Low-brightness lamps assist materially in reducing contrasts in the reflected image of the lighting system and its background. Diffusing luminous ceilings or large panels accomplish this more completely and reduce annoyance from reflections to a minimum. However, in larger rooms and at

*For more complete technology of louver systems see ILLUMINATING ENGINEERING, Vol. XLIV (1949): "Design and Illumination Characteristics of Louver and Louverall Systems," Potter and Oetting, p. 16, p. 341.

*Louverall Lighting Techniques," Benson, p. 89.

*Effect of Luminous Ceiling Elements on Visibility," Benson and Church, p. 715.

*ILLUMINATING ENGINEERING, Vol. XL (1945), p. 525; Vol. XLII (1947), p. 153; *G. E. Review*, Vol. 50, No. 8 (Aug., 1947), p. 31.

TABLE I.—Brightness and Coefficients of Utilization of Selected Lighting Equipments. Approximate Values for 100 Footcandles Maintained in Service. Room Index C. Reflectances: Walls, 0.50; Floors, 0.14; Cavities and Ceiling, 0.75.

Systems	Average Brightness Ft-l. Angle Below Horizontal 15°	25°	Coefficient of Utilization of Generated Light
Louverall (wall to wall): Plastic, 2" Cells, 45° x 45° shielded. Blade Trans. 0.71, refl. 0.19. D/W = 0.056 (shallow cavity)	80	102	0.44
Louverall (wall to wall): Same as above with concentrating reflectors. D/W = 0.347 (deep cavity)	55	86	0.51
Louverall (wall to wall): Gloss White Metal, 2" cells, 45° x 45°. Blade Refl. 0.75. D/W = 0.347 (deep cavity)	59	85	0.31
Louverall (wall to wall): Same as above, with concentrating reflectors	41	45	0.42
Louverall (wall to wall): Matte White Metal, 3" cells, 40° x 40°. Blade Refl. 0.85. D/W = 0.056 (shallow cavity)	64	75	0.40
Louverall (wall to wall): Same as above except Blade refl. = 0.75	57	69	0.35
Louverall (wall to wall): Same as above, except shielding angle of 35° x 35°	58	72	0.38
System of 4' Squares covering 20% of ceiling: Plastic, 2" cells, 45° x 45°. Blade Trans. 0.71, refl. 0.19. D/W = 0.2	340	440	0.49
Glass Panel Troffers, 2 40T12 lamps	610	670	0.51
	Crosswise		
White Troffers, 1 40T12 lamp each, with endwise shielding	101	188	0.60
	Lengthwise		
	154	231	
	Crosswise		
Etched Aluminum Troffers, 1 40T12 lamp each, with endwise shielding	10	26	0.58
	Lengthwise		
	173	284	

the higher illumination values the ceiling itself becomes uncomfortable.

The researches of Benson and Church[6] on veiling glare and visibility for typical office tasks reveal only minor differences among the several lighting systems in a small room, with perhaps some advantage indicated for louverall with low brightness lamps. The increment in cost in using these lamps is a minimum in the case of a louver system.

In the merchandising field reflected grid images appear in glossy goods and glass showcases. If the louver system is carried to the wall, it is difficult to avoid images in the glass top, but they may be largely neutralized by adequate lighting within the case. If the grid system or panels are carried only up to the counter edge, the images are not seen by the customer.

Keeping the brightness contrasts within the cavity as low as feasible is obviously desirable. Tilting of the louver blades is a means of reducing downward brightness of the grid and affords some measure of control of relative values of vertical and horizontal illumination. In a large area the resulting loss in utilization of generated light is not great but becomes substantial in the case of a small room.

Along with quality of illumination, the coefficient of utilization of the generated light is always of interest because it affects both initial and operating costs. In all lighting techniques, control of brightness and other desirable qualities are attained only at some cost in percentage of light utilized. A truer measure of the efficiency of an installation,

(Continued on page 324)

[6] "The Effect of Luminous Ceiling Elements on Visibility," by R. S. Benson, Jr. and F. H. Church. ILLUMINATING ENGINEERING, December, 1948, p. 715.

Figure 3. Louverall of etched aluminum cells, 13" x 13" x 9". Standard warm white fluorescent lamps in rows on 24" centers. Illumination—50 ft-c. Installation in the Central National Bank, Cleveland, Ohio; Conrad, Hayes, Simpson and Ruth, Cleveland—Architects.

Recessed Troffers Have Their Place

By G. W. BEALS

NO SYSTEM of lighting requires more thorough planning than does a recessed troffer lighting system. As such a system is a built-in part of a hung ceiling, it becomes thereby an integral part of the architectural and structural design of the whole interior area to be lighted. Thus, it is a more permanent type of lighting installation, and provision for lighting requirements of the area as well as flexibility of operation must be embodied in the original planning and design layout. Therefore, the planning engineer contemplating a recessed-troffer lighting job must keep in mind that he is designing *not only* the lighting for an interior, *but also* a system which requires more complete integration with the architectural and structural design than does any other lighting system. Neither the lighting layout nor the hung ceiling can be estimated, designed, or installed without co-ordination of the basic requirements and limitations of each.

Recessed-troffer lighting provides a highly efficient and uniform illumination with well-shielded sources and controlled brightnesses. The clean unobstructed ceilings resulting from the built-in feature give an orderly appearance and an air of spaciousness. Such a lighting system harmonizes with any interior, unobtrusive but not monotonous. This unobtrusiveness effectively retards obsolescense, in that the equipment itself is not exposed to view for continual visual comparison with newer designs of fixtures and lamps as they become available and popular.

The functions of a hung ceiling are manifold, in both new construction and remodeling. Typical of these, for example, are the concealment of building services such as air-conditioning ducts, piping, and wiring; the provision of sound-conditioning; the reduction of excessive ceiling height to give more economical operation of heating or air-conditioning systems or more effective sound-conditioning. In all such applications troffers lend themselves to effective use, and they are especially effective in the provision of good lighting under the difficult conditions of a very low ceiling.

Economic considerations are an important consideration in the selection of a lighting system. It must be remembered that, where troffers are under consideration, a false or hung ceiling is a necessary

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Figure 1. An example of recessed-troffer lighting, showing the orderly appearance and air of spaciousness afforded by this type of installation.

Figure 2. Recessed-troffer lighting in an office, providing highly efficient and uniform illumination with well-shielded sources and controlled brightnesses.

Figure 3. Well designed recessed-troffer lighting system in a display and merchandising area.

part of the complete job regardless of the particular luminaire selected. The true cost of such a project, then, is the combined cost of both lighting equipment and ceiling. From the owner's viewpoint, the basic economic comparison is between a recessed-troffer-and-ceiling combination and some form of exposed-luminaire-and-ceiling combination.

Layout of Troffer-Ceiling Installation

The built-in nature of the lighting system requires a certain amount of understanding of hung ceiling construction procedures. Observance of the following suggestion on the part of the planning engineer will pay off in accomplishing a well-designed installation that can be readily and economically constructed.

Module Construction. Most ceiling tiles and wall boards used in hung-ceiling constructions are made on a module of 12 inches. Tiles are generally 12x12 inches or 12x24 inches, and boards may be larger but all have dimensions that are multiples of 12 inches. Troffers are made on the same module. Therefore, it is desirable to lay out the whole ceiling for both troffer and tile on a 12 inch module. Ceiling installation is simplified and cost of material and installation labor greatly reduced by leaving an even number of feet between the edges of troffer rows, both between parallel troffer rows and between ends of troffers in interrupted rows.

Layout Suggestion. In laying out troffer and ceiling patterns of any design, it is advisable to start the layout from the center of the room and work both ways. By this procedure, the layout as a whole is centered in the room, insuring that any fractional parts of the module dimension will occur only along the walls. In actual installation, this procedure reduces cumulative error in laying out the spacing dimensions of equipment.

Layout Precautions. The layout must be coordinated at the earliest possible stage so that space is allowed above the finished ceiling for clearance of beams, ventilating ducts, sprinkler system piping, water pipes, conduit, etc. above or between the recessed lighting equipment. The available space above the finished ceiling determines in many instances the type of lighting equipment that can be employed, and its location.

Layout Requirements. Troffer lighting is a permanent built-in element and not readily revised after installation. Therefore the layout of equipment must be planned not only for current requirements but to remain adequate under advancing standards of good lighting practice for a reasonable future period. The entire interior, wall to wall, should be uniformly lighted so that future re-arrangement of the work area will not create any areas of unsatisfactory illumination requiring revision of the lighting system.

Illumination Levels. Present standards of illumination levels require 30 to 50 footcandles. There is a distinct improvement in ease of seeing when the illumination level is raised from this lower limit to the upper one, and further improvement is found at levels approximating 75 footcandles. At the present time, approximately 50 footcandles in service is a desirable *minimum* for troffer installations. For the average interior, it will continue to be an adequate level for a reasonable future period, although 75 footcandles now can be applied with comfort by careful selection of equipment, and is a suitable value to apply in installations involving critical seeing tasks for extended periods of time.

Selection of Type

For many ordinary installation conditions, it is immaterial whether the single lamp or multiple-lamp types of troffers is used. The choice between them would be largely the preference of the owner as to appearance. Each has certain unique and in-

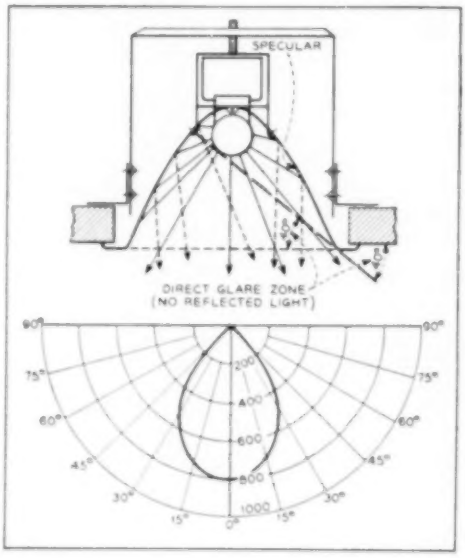

Figure 4. Typical light distribution (normal to troffer) for low brightness troffer.

herent characteristics, however, that normally indicate the selection of one over the other.

Single-Lamp Type. The deep shielding of the lamp, 45 degrees crosswise and 30 degrees lengthwise, and the low brightness of the walls of the reflector when viewed from within the shielded zone are outstanding characteristics. It is almost invariably installed in continuous rows on spacings of from 3 to 5 feet on centers. As the utilization efficiency is high, such spacings provide levels ranging from 35 to 75 footcandles, according to the proportions and size of the interior. The sidewall brightness of single-lamp troffers viewed at any angle from above cut-off is negligible with the maximum being not more than 0.25 candle per square inch. Reflected glare ordinarily is not critical, because of the separate spacings of the low-output single lamps. Reflected glare can be further reduced, however, by employing the low-brightness lamp in which the source brightness is on the order of 2 candles per square inch.

Single-Lamp Installation Conditions. In large area interiors and especially where ceiling height is relatively low, single-lamp troffer characteristics are particularly desirable. The deep shielding, low brightness, and close spacing make possible the same fine lighting that higher ceilings permit. Esthetically, such installations are excellent where inconspicuous unobtrusive lighting is desired.

Single-Lamp Pattern Arrangements. Single-lamp troffers normally are arranged in continuous parallel rows extending parallel to one of the walls of the interior. Variations in this standard arrangement are limited to grouping of fixtures in parallel to form a large area panel. Further variation is restricted because of the difference in shielding crosswise and lengthwise. For drafting rooms, diagonal layouts at an angle of 45 degrees with the drafting boards have been used. An improvement in shadow elimination is obtained by this arrangement but the degree of improvement depends considerably upon the normal angle of elevation of the drafting boards. The greatest improvement occurs for boards elevated to 45 degrees and upward. The installation cost for diagonal arrangement of lighting equipment is greatly increased over the normal rectangular arrangement because of the special fitting of the ceiling materials around side walls and columns. Also the diagonal arrangement often complicates the installation above the finished ceiling of piping, ducts, and other services that are ordinarily located to some extent between troffer rows.

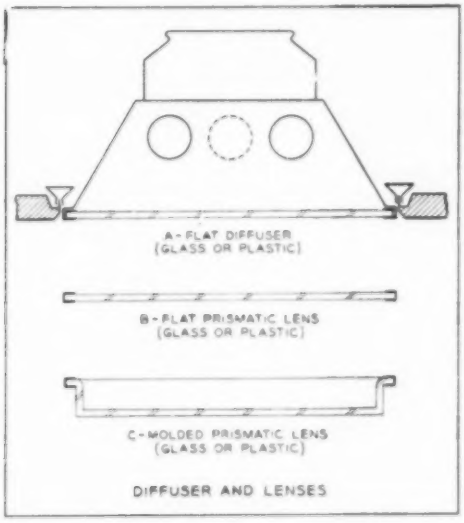

Figure 5.

Figure 6. Module construction troffer-ceiling installation in a store. The system harmonizes with the interior, and is unobtrusive but not monotonous.

Multiple-Lamp Troffers. This type of troffer is extremely flexible in application because of the variable output obtainable from multiple sources, the wide variety of shielding closures available, and the variety of equipment arrangements possible in forming lighting patterns. The lighting performance, as regards output, shielding, and brightness control, will depend almost entirely on the selection of the shielding closure selected. The tables of coefficients and photometric curve data should be examined for the specific fixtures under consideration.

Multiple-Lamp Individual Arrangement. These troffers have sufficient light output to permit their use as individual units if desired. For such arrangement, 3-lamp equipment generally is employed to avoid close spacing in building up suitable levels of illumination. The ratio of spacing to mounting height above the working plane for individually located fixtures should not exceed 3/4 to provide the uniformity of illumination expected of recessed lighting.

Multiple-Lamp—Parallel Row. A common arrangement is parallel rows, with the fixtures either continuous or intermittent. The ratio of spacing to mounting height of rows should not exceed 3/4 ratio. The intermittent arrangement often is employed to obtain economy of installation by the omission of reflectors in suitable sequence to reduce the level of illumination to values currently adequate. For future improvement in lighting levels, reflectors can be inserted to complete a continuous-row pattern.

Multiple-Lamp—Geometric Patterns. Open, closed, or solid-panel patterns are readily accomplished with these troffers. When such layouts are employed, shielding closures having closely symmetrical shielding and brightness values are preferred in order that the lighted appearance of the pattern will be equally effective from any viewpoint in the interior.

Types of Hung Ceiling

A background knowledge of hung ceiling types and their distinctive feature will be of genuine

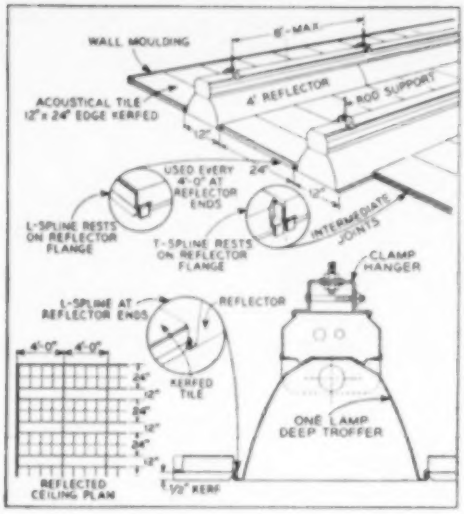

Figure 7. Deep aluminum troffer supports ceiling tiles without furring.

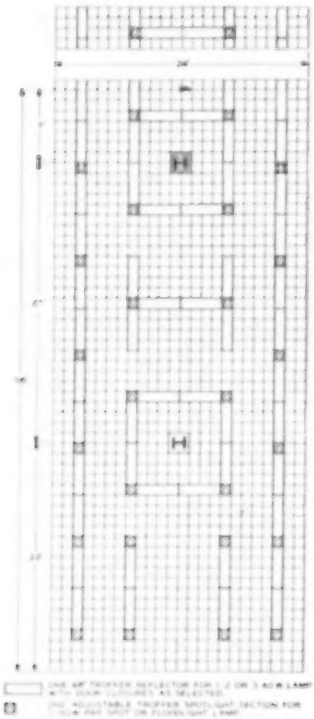

Figure 8. Typical problem of design and installation — store area with recessed troffer lighting in an acoustical ceiling.

assistance to the planning engineer in accomplishing a satisfactory and economical recessed-troffer-ceiling installation. In many of the varied architectural conditions encountered in building structures, some one of these types may be the only practical remedy that makes recessed troffer lighting possible.

Independently Furred Ceilings are those in which the entire furring of the hung ceiling is supported from the structural ceiling of the building. In these hung ceilings, recesses are built to accommodate the lighting equipment which generally is supported in the recess by the furring members. An alternative procedure is to hang the fixture separately from the structural ceiling. Module spacing of equipment in the lighting layout is essential whether the ceiling is of the so-called mechanical furring type with module tile or of composition material such as plaster.

Mechanical Ceilings can be arranged in many instances to permit addition or revision of lighting equipment for future requirements if originally planned that way. Composition ceilings do not permit such flexibility.

Ceilings Supported from Lighting System. In this type, the furring of the hung ceiling is wholly or partially supported by the same hangers that support the lighting equipment, or the ceiling tile may be supported directly by the flanges of the troffer reflectors without furring. In either case, supporting hangers of the lighting equipment carry both fixture and ceiling load. The main purpose is to reduce the cost of installation labor and material so far as the hung ceiling is concerned. Obviously, module spacing must be carefully employed in the lighting layout to gain the economic advantages of this ceiling type. Other advantages include facility to level the ceiling and lighting equipment more readily into mutual alignment. This ceiling construction is a solution for carrying the ceiling span from the lighting equipment supports. It also has the outstanding advantage of leaving the space between rows entirely clear for piping, ducts, and other services.

Ceilings Supported by the Reflectors. The procedure where the ceiling tile is supported directly from the flanges of the troffer reflectors without furring is the most economical of all. It can be employed only where certain conditions are met, but fortunately it is possible in many instances to plan the lighting layout to utilize this procedure. This construction is employed most commonly in connection with single lamp troffers using metal-pan ceiling tiles in lengths of 24 to 48 inches. It also has the advantage of leaving the space above the ceiling between the rows available for overhead installation of building services. The limitations are as follows:

A. Weight limit for a distributed load along the flanges of the reflector must be stated by the fixture manufacturer, and in no case exceeded.

B. Row spacing of the recessed equipment must be such that a single standard tile unit can be supported snugly and firmly on the flanges of reflectors in adjacent rows.

C. Reflector flange must provide means of retaining the tile against accidental upward displacement.

D. Access to the wiring channel must be provided for inspection or repair of ballast and wiring.

E. Ceiling tile used must have sufficient structural rigidity to withstand warping or sagging when so installed.

Coves and Coffers in Planned Lighting

By J. R. JONES

THE COVE and coffer present an opportunity to provide high-quality illumination in an area without appreciably altering the architectural treatment. Like other types of indirect lighting equipment, the cove produces highly diffused illumination, and is widely used in dining rooms, waiting rooms, lobbies and other areas where a soft relaxing atmosphere is wanted. Frequently, it is desirable to supplement the cove with some direct or semi-direct luminaires to add life and drama and to emphasize the form and shape of objects in the room.

There are many types of coves; some are largely decorative, and some purely functional. They are made of various materials and mounted at various distances from the ceiling. The efficiency of a cove is largely dependent on the reflectance of the interior of the cove, the wall between the ceiling and the cove, and, of course, the ceiling itself. Actual contour of cove interior, that is, whether or not corners are filled in, has little effect on efficiency or brightness pattern. The distance of the cove from the ceiling has some influence on efficiency, but is of much less importance than surface reflectances. Tests have indicated that the footcandle level is approximately cut in half if the reflectance of the cove interior is lowered from 85 per cent to about 5 per cent. This is an indication of the importance of maintaining the cove in a clean condition. Reducing the reflectance of the wall between the ceiling and a typical cove from 85 per cent to 5 per cent can be expected to reduce the illumination level about 20 per cent. In selecting a coefficient of utilization, this part of the wall should be considered a part of the ceiling, and generally should be weighted as being about 20 per cent as effective as the ceiling.

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Figure 1. Photograph of a well designed cove installation.

Figure 2 (Left). Typical cove lighting units for fluorescent and incandescent lamps. Fluorescent units are available with either metal or plastic shields. Figure 3 (Center). Schematic diagram illustrating use of self-contained projector of reflector lamps and cove lighting unit employing a lens to control light distribution. Figure 4 (Right).

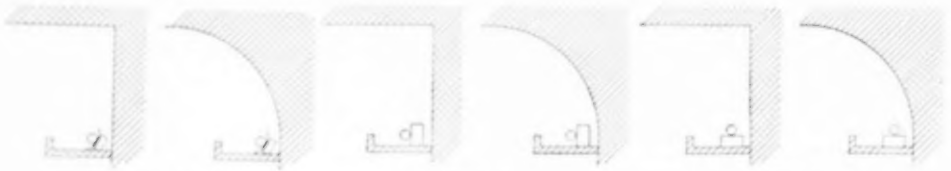


Figure 5. Figure 6. Figure 7.

Light Sources

The shape of the fluorescent lamp makes it an ideal source for most cove applications. A single row of lamps is usually sufficient to produce the necessary level of illumination. Where a single row is used, lamps with a medium bipin base are recommended because the lighted portions of adjacent lamps are near enough together to prevent dark spots behind the lampholders from being noticeable. In coffer lighting where curved or irregular-length lamps are needed, custom-made cold cathode lamps are an excellent solution.

Being a small concentrated source, the filament lamp lends itself to projection of light for some distance, as is frequently necessary in large rooms. Most cove lighting units employ standard 25- to 150-watt lamps; however, projector and reflector lamps also receive wide application because of their self-contained reflectors and good maintenance.

Lighting Equipment

A number of self-contained cove lighting units are available for both fluorescent and incandescent lamps. Most units for fluorescent lamps consist of a channel plus a metal or translucent plastic shield. The incandescent units may or may not employ a lens to control the distribution of light.

If the lighting equipment is to be built into an architectural cove the lamps, either fluorescent or incandescent, are mounted on a channel, several types of which are available. A reflector may be used with either type of lamp, and a lens may also be used with filament lamps.

Brightness Pattern

The purpose of the cove will determine the brightness pattern desired. Decorative coves frequently rely on brightness contrasts to assist in the creation of a mood or an atmosphere. Generally, however, it is the intent of the designer to create as nearly uniform brightness on the ceiling and upper wall surfaces as possible.

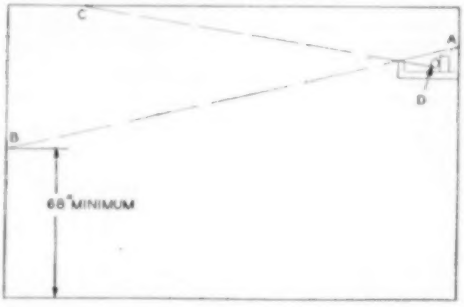


Figure 8. Crossing point of sight line AB and line CD determines position of upper edge of cove lip. The edge of shadow caused by channel will appear at point A. Point C should be a considerable distance from the cove to allow lamp itself to be effective for lighting ceiling near center of room.

Uniform brightness of the wall above the cove can be achieved by recessing the light source into the wall as in Fig. 4. Equally good results may be obtained by using fluorescent lamps in conjunction with a specular reflector tilted up about 20° as in Fig. 5a, if the ceiling and wall meet at a right angle. If the ceiling and wall are continuous (Fig. 5b), reflectors should be used with caution to prevent a sharp shadow at point A. Uniformity satisfactory for most conditions can be obtained with a single row of fluorescent lamps installed end to end instandard medium bipin lampholders provided the

(Continued on page 324)

Guide Posts for Selecting the Proper Fluorescent Lamp

LIGHTING progress has been rapid in recent years and new sources and equipment are constantly being offered to the public. The resulting wide variety has given the architect and engineer practically unlimited scope in applying light to the solution of specific and unique problems.

This variety, however, adds to the complexity of selecting the best source and equipment to solve particular problems. In the case of fluorescent lighting, the many new lamps made available since the war have led to some confusion because of the lack of a complete understanding of the advantages and limitations of the sources. The purpose of this paper, therefore, is to give an impartial analysis of the characteristics of fluorescent lamps on the basis of the many factors that influence the selection of a light source for general lighting.

In studying this analysis the reader will realize that no single lamp is best for all applications. Each lamp, however, does have certain advantages that may make it a "best" to meet certain conditions. It is therefore, important to know the characteristics of the various lamps to permit a fair appraisal for a particular lighting application.

When one considers why the luminaire designer, architect, or building owner selects a certain light source, he finds many factors in addition to cost that influence his choice. Also, the factors important to one group may only be given secondary consideration by another group. The items considered in this analysis are listed in detail in Table I and include dimensional characteristics, efficiency, maintenance, appearance, layout adaptability, and cost. Each factor is expanded in the tables.

TABLE I.—Factors That Influence the Selection of a Light Source.

DIMENSIONAL CHARACTERISTICS—important to designer and luminaire manufacturer
1. Physical
   (a) Length (back to back of sockets)
   (b) Length (luminous portion)
   (c) Diameter
2. Electrical
   (a) Starting voltage required
   (b) Operating current
   (c) Operating voltage
   (d) Two-lamp ballast loss (watts)
3. Photometric
   (a) Lumens
   (b) Lumens per foot
   (c) Brightness
   (d) Temperature sensitivity—light output vs. room temperature

BALLAST HUM

EFFICIENCY—important to the owner and user
1. Lamp only—lumens per watt
2. Lamp and ballast—lumens per watt

MAINTENANCE—important to owner and maintenance supervisor
1. Lamp life
2. Starter required
3. Ease of handling
4. Mechanical strength
5. Lampholder and lamp base design
6. Availability of replacements

COST—important to owner and operator
1. Initial—including installation
2. Fixed charges
3. Power
4. Maintenance

APPEARANCE—important to architect and user
1. Shielded commercial luminaire
2. Bare lamp commercial luminaire
3. Industrial luminaire

LAYOUT ADAPTABILITY—important to architect
1. Length permits satisfactory flexibility in plant
2. Light output satisfactory to provide current practice illumination levels at conventional mounting heights and spacing
   (a) Two-lamp unit
   (b) Four-lamp unit

Dimensional Characteristics

Table II is a breakdown of the various dimensional characteristics of the fluorescent lamps. These characteristics are particularly important to the designer and luminaire manufacturer because they determine luminaire size, its ultimate performance, cost, manufacturing and shipping facilities, and luminaire appearance. This table is divided into three parts: 1) physical dimensions, 2) electrical characteristics and 3) photometric characteristics. The data is really self-explanatory and should be studied carefully by those interested in knowing the difference among the various sources.

The last item on the chart, "Light Output vs. Room Temperature," is seldom mentioned when discussing fluorescent lighting but it is very important to the luminaire designer because it is a definite indication of the way the luminaire will perform under conditions of varying room temperatures. It also shows how different lamps will vary in light output when installed in confined spaces which increase the lamp temperatures.

Ballast Hum

With any reactor or transformer, such as a fluorescent ballast, some audible "hum" can be expected as a result of the alternating magnetic forces in the core and steel case. The makers of fluorescent ballasts are taking every practical step to minimize this hum because of the annoyance that may result, particularly in quiet rooms.

Ballast hum is controllable within limits by certain design and manufacturing techniques and by proper mounting in luminaires. In general, it can be expected that hum will be proportional to the

Data supplied by W. H. Kahler, Westinghouse Electric Corp., Cleveland, Ohio.

TABLE II—Dimensional Characteristics of Florescent Lamps.

	Preheat		Instant Start							
	For Bi-Pin Lampholder		For Single Pin Lampholder							
	I 40W.48" T-12	II 90W.60" T-17	III 40W.48" T-12	IV 38W.48" T-12	V 59W.72" T-12 425 MA	VI 72W.72" T-12 600 MA	VII 51W.96" T-8 200 MA	VIII 69W.96" T-8 300 MA	IX 75W.96" T-12 425 MA	X 96W.96" T-12 600 MA
1. Physical Dimensions:										
(a) Length—nominal	48"	60"	48"	48"	72"	96"	96"	96"	96"	96"
(b) Length—luminous	46½"	57"	46½"	44½"	68⅝"	92⅛"	92⅛"	92⅛"	92⅛"	92⅛"
(c) Diameter	1½"	2⅛"	1½"	1½"	1½"	1½"	1"	1"	1½"	1½"
2. Electrical Characteristics:										
(a) Watts	40	90	40	38	59	72	51	69	75	96
(b) Open Circuit Volts	250	150	450	450	525	525	750	750	625	625
(c) Operating Volts	106	65	106	104	152	137	295	265	195	175
(d) Operating Amps.	.42	1.55	.42	.42	.425	.600	.200	.300	.425	.600
(e) Two-lamp Ballast Loss	17½	37	28	28	38	46	30	39	45	58
3. Photometric Characteristics:										
(a) Initial Lumens	2480	4860	2480	2320	3660	4300	3100	4350	4800	5800
(b) Lumens/foot	620	972	620	580	610	716	412	544	600	736
(c) Brightness (C—sq in.)	4.17	4.7	4.17	4.17	4.17	4.9	4.2	5.3	4.05	4.9
(d) Temperature Sensitivity Light Output vs Room Temperature										
*100°F	93	90†	93	93	93	90	93	90	93	90
80°F	100	100†	100	100	100	100	100	100	100	100
60°F	98	100	98	98	98	110	98	110	98	110
40°F	80	88†	80	80	80	100	80	100	80	100
20°F	48	60†	48	48	48	78	48	78	48	78

*This data, except for 90w. lamp, from "Effect of External Factors on Light Output of Fluorescent Lamps," I. E., Dec., 1946.
†This data estimated from "Low Temperature Performance of Krypton Filled Fluorescent Lamps," G. S. Evans, Natl. Tech. Conf., 1949.

volt-ampere output. That is, with lamps of high starting voltage and high current, a greater hum can be expected than for low voltage and low current lamps. The "brick type" lead-lag ballast for two 40-watt lamps has proven to be exceptionally quiet, and this is a low volt-ampere design. The ballasts for instant start 40-watt and for slimline lamps have a higher volt-ampere rating and, consequently, have a tendency for greater hum.

Where the general noise level is relatively high, as in a factory or large office, even a high level ballast hum may not be objectionable. However, in rooms of lower noise level, such as private offices, libraries, or school rooms, ballast hum should be minimized to prevent annoyance. Where absolute quiet is needed, it may be desirable to mount the ballasts in a separate compartment outside of the room to eliminate even a slight hum.

Light Source Efficiency

Table III lists the efficiencies of the various lamps considered. Item 1 is lamp efficiency only. Item 2 includes ballast loss on the basis of conventional two-lamp lead-lag type. Special ballast circuits may alter these values as illustrated by the sequence starting ballasts. It is interesting to note that the lumens per watt of the lamp only is not a true indication of efficiency because these values do not include the wattage loss in the ballast which is a part of the total wattage consumed by the lighting installation. For example, the 96" T-8 slimline lamp operating at 200 milliamperes shows the highest lamp efficiency but when included with ballast losses the efficiency is no higher than the standard 40-watt T-12 lamp. For purpose of practical comparison it should be noted that the 96" T-8 lamp at 200 and 300 milliamperes and the 96" T-12 at 425 milliamperes have about the same efficiency as the 40-watt preheat lamp. However, the 72" and 48" slimline lamps show considerably lower efficiency. It is shown by these data that instant start lamps to have the same efficiencies as preheat lamps, must have a lamp length of approximately double the length of the preheat lamp.

Maintenance

Table IV, maintenance features, lists six points that would be of importance to the maintenance

TABLE III.—Efficiency.

	Preheat		Instant Start							
	I 40W.48" T-12	II 90W.60" T-17	III 40W.48" T-12	IV 38W.48" T-12	V 59W.72" T-12 425 MA	VI 72W.72" T-12 600 MA	VII 51W.96" T-8 200 MA	VIII 69W.96" T-8 300 MA	IX 75W.96" T-12 425 MA	X 96W.96" T-12 600 MA
1. Lamp only—Lumens/Watt	62	54	62	61	62	60	65	63	64	60
2. Lamp & Ballast Lumens/Watt	51	45	46	43	47	45	51	50	49*	47

*53 L.P.W. when used on 2 lamp leading, non-stroboscopic corrected, sequence starting ballast, 118 v. line.

TABLE IV.—Maintenance Features.

1. Rated Average Lamp Life	7500	7500	5000†	5000†	5000†	5000†	5000†	5000†	5000†	5000†
2. Starters required	Yes	Yes	No	No	No	No	No	No	No	No
3. Ease of handling	Good	Good	Good	Good	Fair	Fair	Poor	Poor	Poor	Poor
4. Lampholder and lamp base design	Poor**	Fair	Poor**	Good	Good	Good	Good	Good	Good	Good
5. Availability of replacements*	Good	Fair	Fair	Poor	Poor	Poor	Fair	Fair	Fair	Fair

*This factor will vary with demand.
**Good with heavy duty lampholder.
†Estimated lamp life at 6 hours per start.

TABLE V.—Appearance.

Type of Luminaire	Preheat		Instant Start							
	I 40W.48" T-12	II 85W.60" T-17	III 40W.48" T-12	IV 30W.48" T-12	V 59W.72" T-12 425 MA	VI 72W.72" T-12 600 MA	VII 51W.96" T-8 200 MA	VIII 69W.96" T-8 300 MA	IX 75W.96" T-12 425 MA	X 86W.96" T-12 600 MA
1. Shielded Commercial	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
2. Bare Lamp Commercial	Poor	Poor	Poor	Poor	Fair	Fair	Good	Good	Good	Good
3. Industrial	Fair	Fair	Fair	Fair	Good	Good	Good	Good	Good	Good

supervisor. Point 1, lamp life, shows that instant start lamps have a shorter life than preheat lamps (with starters). This is one of the penalties that must be weighed against the added convenience of the elimination of starters. The complete effect of this shorter life on overall lighting economics is indicated in the cost analysis (Chart I).

Point 3, ease in handling, indicates the advantage of shorter lamps. With point 4 it is shown that slimline lampholders are a great improvement over the conventional light duty lampholder for the bi-pin lamp. However, it should be also noted that the newer heavy-duty lampholder for the bi-pin lamp eliminates practically all of the objections that were found with the light duty lamp holder.

Point 5, availability of replacement would be of greatest importance to the small user who would expect to buy lamp replacements from a small neighborhood store, or a small jobber. At the present time the 40-watt preheat lamp is available at numerous retail locations but one would expect to purchase the slimline lamps only from jobbers.

Installed Appearance

Table V indicates the relative appearance of installations using the different types of lamps. In most shielded commercial luminaires lamp length has little effect on appearance as the shielding conceals the lampholders and often it is difficult to determine whether a four- or an eight-foot lamp is actually used. However, with bare lamp commercial luminaires the length of the lamp has a direct bearing on appearance because the longer lamp requires fewer lampholders which generally detract from the streamlined appearance. Back to back spacing of lampholders also improves appearance. This same consideration applies to industrial luminaires but is probably of minor importance because appearance is not a prime factor in selecting industrial lighting equipment.

Layout Adaptability

Table VI, layout adaptability, recognizes that the shorter fluorescent lamp permits greater flexibility in making layouts, particularly in small rooms. For example, it has been found that 8-foot luminaires are difficult to use in layouts for small offices because a room dimension of 16 feet or less will not permit the installation of two 8-foot units end to end and one such unit is insufficient. In many cases a luminaire for the 72" lamp would greatly improve this situation but the luminaire for 48" lamps has proved particularly satisfactory for layouts in small rooms.

With lamps of the T-12 diameter in 48", 72" and 96" lengths, excellent layout flexibility is achieved, however, when luminaires are made in the same design for all three lamps.

Under point 3 it is recognized that the light output of certain lamps is more satisfactory than others in planning layouts for given illumination levels specified according to current practice and at conventional mounting heights and spacing. Lamps with high lumens per foot may prove satisfactory in two-lamp luminaires but are not suitable in four-lamp equipment because the spacing becomes too great for uniform illumination at the given mounting height. In contrast, however, lamps with low lumens per foot are more suitable for equipment designed for four lamps.

TABLE VI.—Layout Adaptability.

1. Length permits satisfactory flexibility	Good	Fair	Good	Good	Fair	Fair	Poor	Poor	Poor*	Poor*
2. Permits luminaire designs of same cross section, but different length	Good	Poor	Good	Good	Good	Good	Fair	Fair	Good	Good
3. For good layout with:										
(a) Two-lamp units	Good	Good	Good	Good	Good	Good	Poor	Fair	Good	Good
(b) Four-lamp units	Good	Fair	Good	Good	Good	Fair	Good	Good	Good	Fair

*Good when used in combination with 48" or 72" trimmer units.

Over-all Lighting Cost

Chart I is a summary of a detailed analysis of the annual lighting cost for a typical office area of 1800 square feet. The luminaire was the direct-indirect type for 4 lamps and suspended below the ceiling. The installation was planned for 50 foot-candles and it was assumed that annual operations would be 3000 hours at a rate of 2c per kilowatt hour. The fixed charges were obtained by estimating the total installation cost and amortizing this amount over a 10-year period. Also included in the fixed charges was an allowance of five per cent on this initial investment for interest, taxes and insurance. The cost of maintenance included lamp replacement and cleaning. A charge of 25c per lamp was made for the labor cost of renewing each lamp. It was assumed that all luminaires should be cleaned three times per year and the cost of cleaning a luminaire was apportioned according to its length. Where luminaires included starters, it was assumed that a starter replacement would be approximately 20 per cent of lamp replacements.

Summary

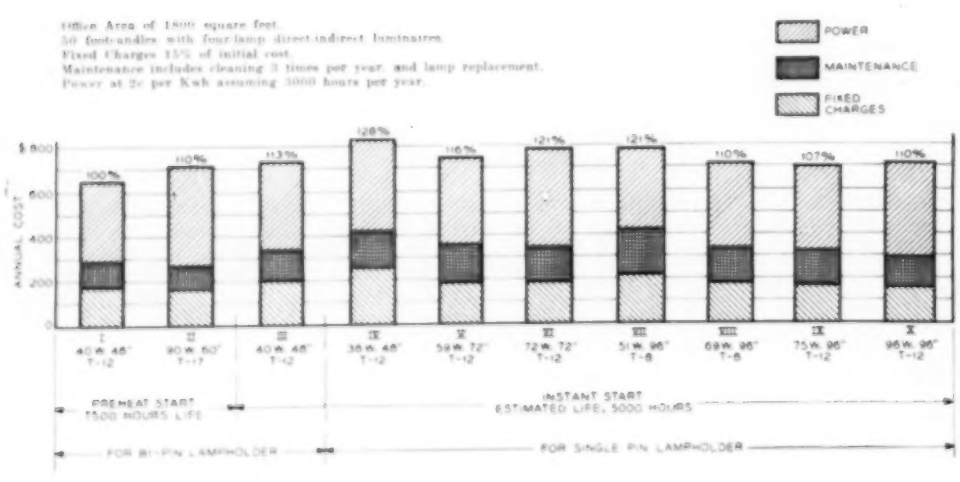
In studying this cost analysis we should remember that it is based on only one set of conditions. Variations in such factors as power rate, operating hours, depreciation and maintenance may alter the relative economy of different lamps. An analysis should be made for the specific conditions of an application for the most accurate cost comparison.

It is impossible to draw a conclusion that a single source is the best, because the luminaire designer, architect and the customer will place different degrees of importance on the various factors that influence the selection of the light source. We can, however, summarize a few of the main advantages and disadvantages of the lamps analyzed.

The 40-watt preheat lamp still appears to be the most economical and has many other points in its favor. The main objection is that starters are required. The short pins on the base have caused some difficulty in the past, but the new heavy duty lampholders are eliminating the cause of this

(*Continued on page 325*)

CHART I.—Annual Cost of Lighting Analysis.



Indoor Sports Lighting

By CARL J. ALLEN

THE LIGHTING requirements of various indoor sports vary both as to recommended illumination levels and lighting techniques.

The lighting level recommendations depend upon the severity of the visual task and whether the game is to be played recreationally, or competitively, or exhibitionally before an audience. The recommended recreational levels are adequate where the play is strictly for fun and exercise. The higher levels recommended for more skilled play serve to enhance the exhilaration and enjoyment of playing or watching the game, and recognize that the visual requirements in any game become more severe as the caliber of play becomes higher.

The lighting techniques suitable for each sport depend upon such considerations as the normal lines of sight of players and spectators, and the nature of the area in which the game is played. For example, badminton is a fast action sport in which most of the play is overhead. In contrast, bowling is a deliberate sport wherein all the visual attention is below eye level.

Gymnasium Lighting

Recommended Levels	
College Games	50 Ft-c minimum
High School Games	30 Ft-c minimum
General Recreation	20 Ft-c minimum
School Assemblies	10 Ft-c minimum
School Assemblies	10 Ft-c minimum

The school gymnasium is a multi-sport center which serves the student body during the daytime and in many cases the community at night. It is used for dances where the preferred lighting key is low and colorful, for assemblies where the lighting is primarily for atmosphere, for general exercise and recreation where the lighting assures safe and adequate performance, and last, for games and exhibitions where substantially higher levels are required both for players and spectators. The lighting for general recreation will be used for the longest periods and hence may be considered the basic system. The lower levels can be obtained by proper circuiting. The higher levels, needed for exhibition events, may be best attained by means of a supplementary system.

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Many school gymnasiums use their lighting systems up to 2000 hours per year. The basic level in such cases is generally attained more economically with fluorescent lighting than with filament. On the other hand, the hours of use for exhibition play may be only a hundred hours or so per year in which case filament lighting is more economical.

The layout of the basketball court shown as Fig. 1 shows a combination lighting layout using fluorescent for long hours of recreational use and supplementary filament for short hours of exhibition use. This layout is suggested in response to requests for illumination levels substantially higher than the minimum recommendations above. The hundred-footcandle level attained with the two systems not only provides good lighting for the distant spectator but also permits televising and the taking of high-speed motion pictures for analyzing playing techniques. In this layout the wattage of the filament lamps in the corner lighting units is increased fifty per cent in order to bring the illumination in

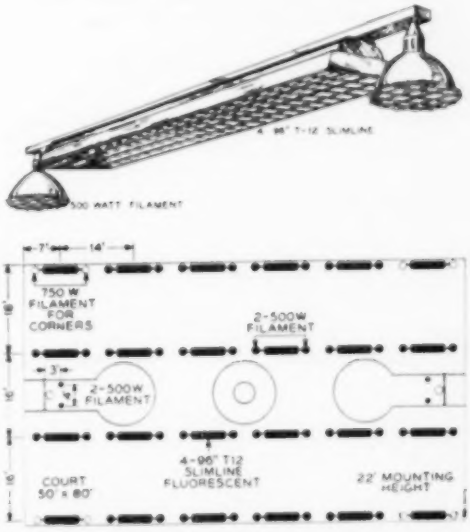

Figure 1. Basketball court layout to maintain 35 footcandles from fluorescent lighting for recreational play and 100 footcandles from combination system for exhibition games. Filament lamps to be operated 10 volts over voltage. Suggested luminaire is shown at top.

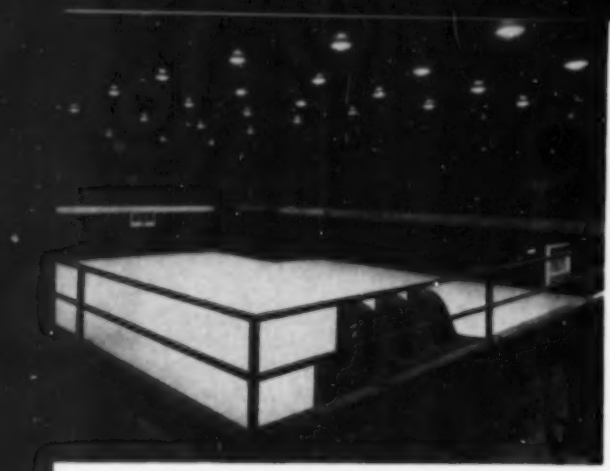

Figure 2 (Left). David Lipscomb College Gymnasium. 1500-watt filament lamps in medium spread highbay reflectors on approximately 16-foot centers will provide about 65 footcandles in service (95 footcandles initial) on the playing court. Figure 3 (Right). Colgate University. Continuous rows of industrial-type reflectors on 20-foot centers, each equipped with four 96T8 slim fluorescent lamps at 300 milliamperes, provide 45 footcandles in service on the court.

the court corners up to the average of the rest of the court. The most critical play takes place in the pivot shot area beneath the basket and it is recommended that two medium-spread 500-watt filament units aimed directly downward be located about 4 feet apart and 3 feet in front of the backboard.

In large gymnasiums and field houses where a reasonably high level of illumination is desired over long periods, the combination of filament and mercury lighting may be considered. A system supplying approximately equal lumens of filament and mercury provides light of near-white color satisfactory for the playing area. Such a combination approaches the low initial cost of a filament installation and the higher efficiency of a fluorescent system. This type of lighting is especially suited to high mounting heights where maintenance is difficult. Twin units each containing, for example, one 400-watt mercury and one 1000-watt filament lamp may be mounted together and lowered on one disconnect hanger for easy cleaning and servicing.

Filament lamps which may be used only two or three hundred hours per year may well be operated about 10 per cent overvoltage — that is by using lamps of voltage rating 10 volts under the socket voltage. The light output is thus increased about a third, the wattage increased about a sixth, and the life reduced about three-fourths.

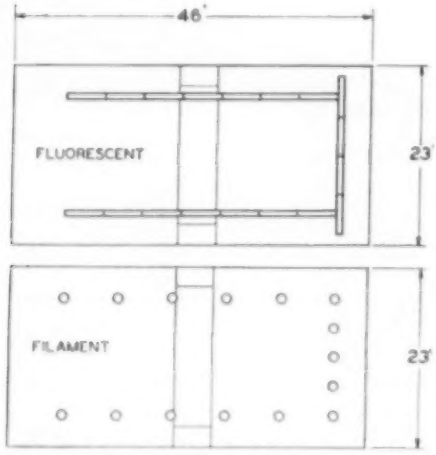

Figure 4. The fluorescent layout of a squash and handball court, uses 18 40-watt T17 low brightness lamps in etched aluminum troffers and is suitable for recreational play. The filament system uses 15 200-watt wide spread etched aluminum reflectors for club play. Tempered glass covers should be used to protect the equipment.

Badminton

Recommended Levels

Tournament	30 Ft-c
Club	20 Ft-c
Recreational	10 Ft-c

The principal requirements in this aerial sport are to light the bird uniformly throughout its travel to a higher brightness than its background and to avoid areas of high brightness in the players' field of view. Many lighting systems are in use and have their staunch advocates. One active badminton club developed an open-top V-shaped luminous element covered with white cloth and equipped with 200-watt lamps on 12-inch centers. These units are suspended horizontally about seven feet from the floor on both sides of the court and extend about two thirds of the length of the court. Expert players who have played under this lighting consider it outstanding.

Figure 5 (Left). For home table tennis, two deep white shades with 150-watt filament lamps provide acceptable results with low-cost equipment. Figure 6 (Right). Two 96-inch T12 slim fluorescent lamps operated at 425 milliamperes in a louvered reflector provide excellent uniformity and low source brightness for playing table tennis in this recreation room.

Squash and Handball

Recommended Levels	
Tournament	30 Ft-c
Club	20 Ft-c
Recreational	10 Ft-c

These two sports involve the visual task of following a rapidly traveling small black ball which changes direction frequently and abruptly. Seeing the ball is greatly facilitated by silhouetting it against the walls and floors which are light in tone and well illuminated. A horseshoe arrangement of either troffer-type fluorescent units or wide-spread filament reflectors lights the side walls effectively.

Figure 7. Sports Bowl, Sioux Falls. Continuous rows of two-lamp 40-watt equipment concealed behind the step backs of each sloping ceiling section provide uniform lighting on these lanes.

Table Tennis

Recommended Levels	
Tournament	50 Ft-c
Club	30 Ft-c
Recreational	20 Ft-c

Table tennis requires particularly fast visual-muscular coordination. It is generally played as a home sport where head room is at a premium.

Skilled tournament players frequently play ten to fifteen feet or more back of the table. Good lighting for tournaments is provided by two rows each of five deep white reflectors with 200-watt inside-frosted lamps, operated 10 volts above rating, located 6 feet above the table on 7-foot centers and over both edges of the table.

Bowling

Recommended Levels		
	Lane	*Head Pin*
Tournament	20 Ft-c	50 Ft-c (vert.)
Recreational	10 Ft-c	30 Ft-c (vert.)

The visual interest in bowling is on the lane with increasing emphasis up to the pins. One arrangement suitable for tournament play employs two-lamp 40-watt asymetrical reflectors directed away from the bowler and located about 11 feet above each lane on spacings 13 ft, 11 ft, 11 ft, 10 ft and 10 ft from the foul line. The units should be shielded so that neither the lamps nor their images in the lanes can be seen by the bowler. This may be accomplished by a saw-tooth ceiling or by vertical shields which conceal the lighting equipment. Suitable head pin illumination is attainable by one 300-watt reflector floodlight, or preferably two 150-watt reflector floods, shielded from the bowlers' view and located about three feet in front of and above the head pin.

A Basis for Programming Street Lighting

By W. T. SOJEBA

The City of Cleveland during the past two years has installed and modernized approximately 8650 street lighting units. This program has been carried out by the two utilities serving the Cleveland area — the Division of Light and Power of the City of Cleveland, and the Cleveland Electric Illuminating Company. It represents about 200 miles of improved street lighting. All of it conforms to the recommendations in the American Standard Practice for Street and Highway Lighting.

CLEVELAND'S extensive program of street lighting has had two broad objectives. One is the reduction of night traffic fatalities. The value of good street lighting in safeguarding and facilitating night traffic is thoroughly established and has been verified by many studies. The other objective is to light streets and sidewalks so that people may walk in comfort and without fear of molestation. Good lighting, law-enforcement officials attest, is at the same time a powerful deterrent to street crimes.

In the Cleveland program, the compilation of a "Roll of Casualtyways" was the first step. Spot maps were prepared showing the number and location of all traffic fatalities over a period of six years. Chart No. 1 shows a portion of the "Roll of Casualtyways" arranged in the order of the number of night fatalities per mile of street. Even in this limited sampling, the differences are striking. Clearly this roll offers one criterion in determining where money spent for lighting improvement would make a valuable contribution to public safety.

Second, a "Roll of Fearways" was compiled. A Fearway might be defined as a street which has a serious deficiency in illumination. Along such streets, people cannot see their way to walk in com-

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"Before and After" photographs of the lighting of

fort. They do not feel safe; and their fear is not just an inherent dread of darkness. Poorly lighted streets all too often invite annoyances, molestations, and acts of violence. Cleveland has had its share of such experiences, and city officials and townspeople alike have insisted that corrective action be taken — in the way of lighting improvements as well as in other enforcement activities.

The existing illumination was calculated for each street, and its per cent of the recommended value in American Standard Practice determined. The reciprocal of the sufficiency in lighting — or, stated another way, the per cent of lighting *deficiency* — is used in Chart No. 2. This chart, presenting a portion of the "Roll of Fearways," offers another criterion in determining where lighting improvement would be valuable in public safety.

The basis of the Cleveland programming has been a combination of these two factors, the Casualty-way and the Fearway. True, the units in the two charts are different and any combination is in part arbitrary. As a trial, one traffic fatality per mile was taken to be equivalent to ten percentage points in lighting deficiency. The resulting consolidation is shown in Chart No. 3. This consolidation gave results which, at least for conditions in Cleveland, were judged to be logical.

On this basis all the streets in the city carrying more than local traffic have been tabulated and arranged in order of priority. The order of street lighting improvements has followed this list with but few exceptions. For example, revision was made in the priority list to provide extended stretches of lighting rather than intermittent short sections.

Another factor which influenced the order of priority was coordination of the street lighting program, in some instances, with the activities of the City Transit System in replacing trolley poles. The City of Cleveland has adopted a street lighting standard which is unique. It is designed for use as a street lamp standard, a trolley support, or both. The general appearance remains the same regardless of application, but varies structurally in use. It results in a minimum number of poles along the street, and also substantial saving in overall pole cost. This joint pole program modified the lighting priority list slightly.

An example of the lighting employed in the Cleveland program is shown in the "before and after" photographs of Lake Shore Boulevard. Lake Shore Boulevard carries medium vehicular traffic and light pedestrian traffic. The lighting comprises reflector-refractor luminaires, 25 feet high, 6 feet overhang, average spacing 110 feet in staggered arrangement, with 10,000-lumen lamps. Approximately 0.8 average footcandles initially.

The 1950 program contemplates additional street lighting modernization to the extent of roughly 100 miles of streets. Further, the local Automobile Club has organized a committee to make experi-

Lake Shore Boulevard, Cleveland.

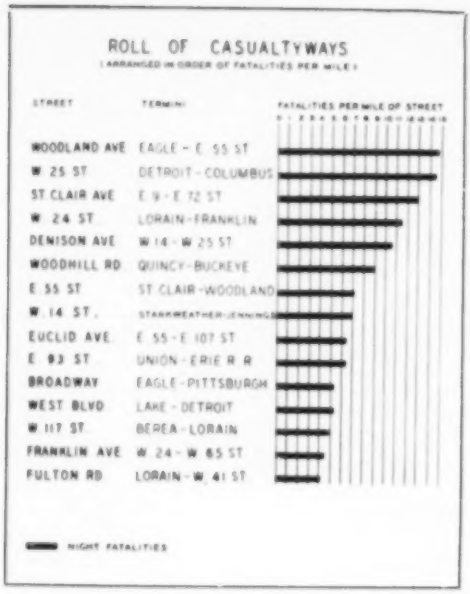

ROLL OF CASUALTYWAYS
(ARRANGED IN ORDER OF FATALITIES PER MILE)
STREET
TERMINI
FATALITIES PER MILE OF STREET
WOODLAND AVE EAGLE - E 55 ST
W 25 ST DETROIT - COLUMBUS
ST CLAIR AVE E 9 - E 72 ST
W 24 ST LORAIN - FRANKLIN
DENISON AVE W 14 - W 25 ST
WOODHILL RD QUINCY - BUCKEYE
E 55 ST ST CLAIR - WOODLAND
W 14 ST. STARKWEATHER - JENNINGS
EUCLID AVE E 55 - E 107 ST
E 93 ST UNION - ERIE R R
BROADWAY EAGLE - PITTSBURGH
WEST BLVD LAKE - DETROIT
W 117 ST BEREA - LORAIN
FRANKLIN AVE W 24 - W 65 ST
FULTON RD LORAIN - W 41 ST
NIGHT FATALITIES

Chart 1.

ROLL OF FEARWAYS
(ARRANGED IN ORDER OF LIGHTING DEFICIENCY)
STREET
TERMINI
LIGHTING DEFICIENCY
WOODHILL RD. QUINCY - BUCKEYE
BROADWAY EAGLE - PITTSBURGH
DENISON AVE W 14 - W 25 ST
W 117 ST BEREA - LORAIN
WEST BLVD LAKE - DETROIT
FULTON RD LORAIN - W 41 ST
W 24 ST LORAIN - FRANKLIN
FRANKLIN AVE W 24 - W 65 ST
EUCLID AVE E 55 - E 107 ST.
ST CLAIR AVE E 9 - E 72 ST
E 93 ST UNION - ERIE R R
W 14 ST STARKWEATHER - JENNINGS
WOODLAND AVE EAGLE - E 55 ST
E 55 ST ST CLAIR - WOODLAND
W 25 ST DETROIT - COLUMBUS
LIGHTING DEFICIENCY IN % OF ILLUMINATION RECOMMENDED BY AMERICAN STANDARD PRACTICE

Chart 2.

ments for the evaluation of the reflectance characteristics of various types of pavement surfaces in use in Cleveland. Tests to date have indicated that substantial improvement in night visibility can be had, at little or perhaps no increase in pavement costs, where surfaces are provided with more favorable reflectance characteristics. It is the intent early this spring, when weather permits the resumption of pavement resurfacing projects, to incorporate some of the findings of the committee in the actual pavement work. Various aggregates of favorable reflectance qualities are to be applied to test sections of newly resurfaced streets. Measurements of reflectances throughout the ensuing two or three years will confirm the degree of gain.

Chart 3.

CLEVELAND STREET LIGHTING PROGRAM

CONSOLIDATION OF TRAFFIC FATALITIES AND LIGHTING DEFICIENCIES
(STREETS ARRANGED IN ORDER OF PRIORITY)

STREET	TERMINI	PRIORITY FACTORS: FATALITIES	LIGHTING	TOTAL
WOODLAND AVE.	EAGLE - E 55 ST	14.8	7.0	21.8
ST CLAIR AVE	E 9 - E 72 ST	13.0	7.8	20.8
W 25 ST	DETROIT - COLUMBUS	14.5	6.2	20.7
W 24 ST	LORAIN - FRANKLIN	11.5	9.1	20.6
DENISON AVE	W 14 - W 25 ST	10.6	9.4	20.0
WOODHILL RD	QUINCY - BUCKEYE	9.0	9.7	18.7
BROADWAY	EAGLE - PITTSBURGH	5.3	9.7	15.0
EUCLID AVE.	E 55 - E 107 ST	6.4	8.4	14.8
WEST BLVD	LAKE - DETROIT	5.3	9.2	14.5
W 14 ST	STARKWEATHER - JENNINGS	7.0	7.4	14.4
W 117 ST	BEREA - LORAIN	4.9	9.4	14.3
E 55 ST	ST CLAIR - WOODLAND	7.1	6.9	14.0
E 93 ST	UNION - ERIE R R	6.4	7.5	13.9
FRANKLIN AVE	W 24 - W 65 ST	4.5	9.1	13.6
FULTON RD	LORAIN - W 41 ST	4.2	9.2	13.4

The residents of Cleveland and communities have enjoyed for at least one full year the benefits of the expanded street lighting program inaugurated in 1948. The benefits of the 1949 program have not yet been fully realized. Nevertheless, it is gratifying to note that pedestrian traffic fatalities at night were 31 per cent lower in 1949 than in 1947. A fact that makes this figure very significant is that during this same period, daytime pedestrian fatalities increased 70 per cent. This is further evidence that good street lighting is a major factor in the saving of human life upon the streets.

Engineering and construction problems are beyond the scope of this article. Nevertheless it would be remiss to conclude without acknowledgment that the Cleveland street lighting program could not have been carried out so promptly and so effectively without the full cooperation of the engineering and construction staffs, as well as the management, of the two utilities.

Planning for Minimum Maintenance

By NEAL JACOBUS

For a properly engineered and planned lighting system, *maintenance*, the housekeeping plan for the installation, must be given special attention. When it is realized that 50 per cent of the initially available light may be lost, the importance of this factor is at once evident. The system must deliver economically a required level of illumination during the period of years following the installation. With planned lighting must go planned maintenance for continued efficiency, comfort and economy.

LIGHTING maintenance includes everything connected with keeping the output of a lighting system as near to its initial level as is economical. For an engineering approach to the problem of minimizing maintenance cost, we must first understand how significant a factor this maintenance is. Then we should review the presently adopted methods of allowing for, and reducing maintenance.

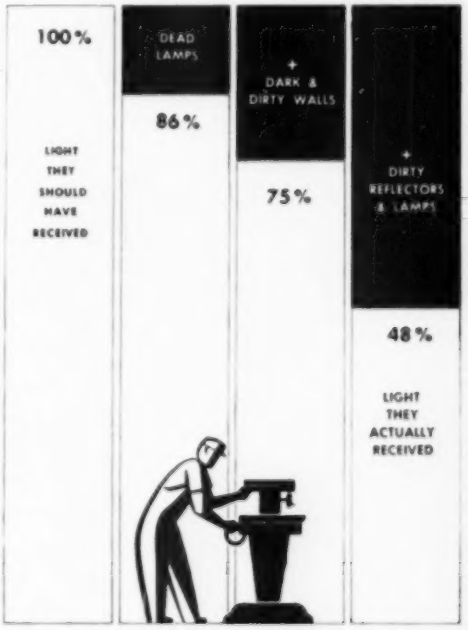
The "housekeeping" for a lighting system has two phases — that which is routine, such as lamp replacement and cleaning; and that which is unexpected, such as repair or replacement of parts that fail before their normal expected life. A well planned installation will reduce the routine maintenance to a minimum, and will eliminate unnecessary maintenance.

Determining Expected Reduction in Level of Illumination*

In order to plan for routine maintenance we must be able to estimate the degree to which it affects the initial level of illumination. Several studies have been made in an attempt to arrive at a reasonably accurate method of determining this reduction in illumination. The most logical method is to consider (1) lamp depreciation, (2) dirt collection, and (3) cleaning and relamping policy.

With these three factors as carefully established as possible, we can arrive mathematically at a composite value or Maintenance Factor. Even the most carefully presented studies offer their factors as suggested or typical, recognizing their limitations as far as accuracy is concerned.

Lamp depreciation can be measured in the laboratory, and some manufacturers are now publishing average light output values. Typical curves, showing the rate of lamp depreciation with time, have been published previously in ILLUMINATING ENGINEERING. For fluorescent lamps the average light output amounts to about 85 per cent of the initial 100-hour rating. For medium wattage incandescent lamps the light output at 70 per cent of designed life is 90 per cent of initial, while for higher wattages this value drops as low as 70 per cent. The variation in these values alone shows



Maintenance factors.

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*The material in this section is based on work of A. K. Gaetjens, published as "A Guide to Realistic Maintenance Factors for Lighting Installations," ILLUMINATING ENGINEERING, p. 307, May, 1945.

the need for careful consideration of what reduction in illumination is to be expected.

The effect of dirt collection is difficult to determine with accuracy, but there are data available which serve as useful guides. The dirt collection factor depends on both the type of luminaire, and the type of installation. For a direct type luminaire with some air circulation around the light source, installed in a clean room where clean work is being done, 90 per cent has been suggested. If all the lamps in such an installation are replaced upon burnout, and cleaning is done periodically, we then have the best possible maintenance conditions.

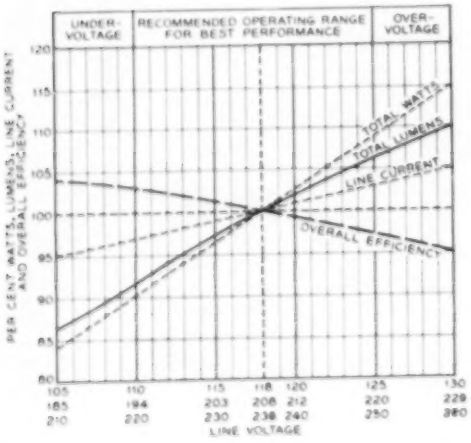
Based on this analysis, we can see the limits between which the Maintenance Factor comes for typical conditions. Using a lamp depreciation factor of 90 per cent, and the highest factor for dirt collection (90 per cent), the overall Maintenance Factor would be 81 per cent. That then may be considered the highest practical value. On the other extreme, if a commercial luminaire of an indirect or closed bottom type is installed in a dirty location, a dirt collection factor of 60 per cent would apply. Combining this with a lamp depreciation of 85 per cent, the resultant Maintenance Factor would be 51 per cent. This means that only 51 per cent of the initial illumination will be obtained over a period of time. Obviously this condition would not be acceptable, and a different choice of equipment must be made, or a schedule of frequent cleaning must be established.

At very best, we must expect a 20 per cent reduction in the initial level of illumination. Under less ideal conditions, the expected reduction may amount to 30, 40, or even 50 per cent. These are highly significant amounts and if not properly considered and planned for or reduced, will result in an unsatisfactory lighting system.

Reducing Routine Maintenance

Equipment selection and installation must be made with maintenance as a basic consideration. Lamp depreciation has been minimized by careful lamp design. Obviously at the end of lamp life, a replacement must be made and plans for economical replacement are necessary. Replacement must be easy, and in general from below the equipment and without the use of tools. The luminaires must be installed so that they are accessible. Mounting heights up to 12 feet can be serviced from a step-ladder or with a pole lamp-changer. For greater mounting heights, special ladders, platforms or disconnecting hangers are required. With such mounting heights also, higher wattage units are desirable so as to reduce to a minimum the number of units to be serviced. The use of long life lamps is often advisable in inaccessible places such as high coves.

For large installations, or where lamps are relatively inaccessible, a planned replacement program is recommended. This has been called the "group replacement plan." For a fluorescent installation, such a plan recognizes that after 5000 hours of burning, lamps rated at 7500 hours will start to



Effect of line voltage on fluorescent lamp performance.

Maintenance of high mounted lighting units.

TABLE I.—Suggested Guide of Maintenance Factors.†

Type of Reflector and Cleanliness Condition of Interior			Dirt Collection Component of Maintenance Factor Per Cent	Lamp Depreciation Component of Maintenance Factor					
				Per Cent Lamp Light Output at 70% of Actual Life					
Industrial Direct Reflectors	Commercial			90	85	80	75	70	65
	Totally Enclosed and Open Bottom Units*	Indirect** and Closed Bottom Units		Overall Maintenance Factor (Product of Two Components)					
Clean Work, Cleaned Air	Cleaned Air		90	.81	.76	.72	.68	.63	.58
Clean Work	Very Clean Location	Cleaned Air	85	.76	.72	.68	.64	.60	.55
Some Fumes or Dirt	Better than Average Location	Very Clean Location	80	.72	.68	.64	.60	.56	.52
Average Machine Shop	Average Urban Location	Better than Average Location	75	.68	.64	.60	.56	.52	.49
Heavy Fumes or Dust	Dirty Urban Location	Average Urban Location	70	.63	.60	.56	.52	.49	.46
Foundry or Heavy Welding	Very Dirty Location	Dirty Urban Location	65	.58	.55	.52	.49	.46	.42
Extremely Dirty Location and Work		Very Dirty Location	60	.54	.51	.48	.45	.42	.39

*Many industrial operations originate dust, fumes or other dirt which contribute to the depreciation of lighting equipment in such areas. This is rarely true of interiors lighted with commercial luminaires. However, the design of commercial luminaires usually is not intrinsically as favorable to good maintenance as industrial reflectors. Both factors have been considered in the comparative values shown above.

**Depreciation of Silvered Bowl luminaires one step better than other indirect.

†Reprinted from "A Guide to Realistic Maintenance Factors for Lighting Installations," by A. K. Gaetjens, ILLUMINATING ENGINEERING, Vol. XL, No. 5, p. 308 (May, 1945).

burn out. Since rated life is an average value, some lamps will fail before that time — some will burn longer. Present experience is that very few fail prior to 5000 hours. If the entire installation is relamped at this time, considerable savings can be realized in cost of labor. This labor savings more than offsets the value of any lamps still burning. The same plan is also practical with incandescent installations, for which lamp replacement should be made between 60 and 80 per cent of rated life.

In all installations, the reduction in illumination due to dirt is a principal factor, and cleaning of equipment should be routine. Cleaning can often be coordinated with a lamp replacement plan.

To minimize the effect of dirt, however, there should be air circulation through the luminaire. Indirect or closed bottom units should not be used where conditions of excess dirt will exist, or where a cleaning program is not established. With indirect equipment special consideration must also be given to the ceiling, since that is the principal light reflecting surface. With installations of this type especially, the ceiling must be washed or painted periodically.

Eliminating Unnecessary Maintenance

Completely unnecessary maintenance can be avoided only with the installation of proper equipment of high quality. Short life with incandescent lamps, for instance, is caused primarily by improper voltage and vibration. There are available lamps designed to operate at various voltages, and above average voltage, with good life performance. Vibration and rough service lamps are also available, designed to give good performance under severe operating conditions.

Heat is a problem of many types of equipment, and while excessive heat does not affect the filament life, it may cause blistering of the bulb, corrosion of the base, or loosening of the base. Ventilated luminaires should be recommended where higher wattages are used, and for high heat conditions, special mechanical bases on lamps are available.

Heat is the primary problem with fluorescent lighting. While excessive heat affects the efficiency of the lamp and reduces the light output, the more serious trouble develops with over-heating of auxiliary equipment. This heating condition may develop because the ballast was improperly installed or the ambient temperature is too high. The most common cause of excessive temperature is the condition that results when the starter of a preheat type of fluorescent lamp is shorted so that preheat current runs continually through the ballast. Such a condition almost doubles the ballast loss and therefore doubles the operating temperature. Where ambient temperatures are expected to be high, it is advisable to use pendant mounted fluorescent fixtures. Experience has shown that where fluorescent fixtures are mounted directly to ceilings of non-conducting material, such as acoustic tile, they tend to over-heat and an air circulation around the fixture is necessary to eliminate trouble.

General Lighting—*Commercial*

By R. L. ZAHOUR

The subject of general lighting in the commercial field obviously is too broad to be dealt with comprehensively in an article of this nature. Hence, two representative and important phases of the subject have been selected for review here with reference particularly to the engineering that underlies a well planned general lighting job. lighting job

Part I—Store and Window Lighting

ALL SHOPPERS are potential buyers, and merchants bid for each prospect's patronage and his dollar. Usually, pedestrians take three to four seconds to walk past an average show window, and a progressive merchant seeks any effective method that will attract the attention of these sidewalk prospects. Since about 87 per cent of our impressions are received through seeing, good window lighting is the most effective means of attracting the attention of passersby.

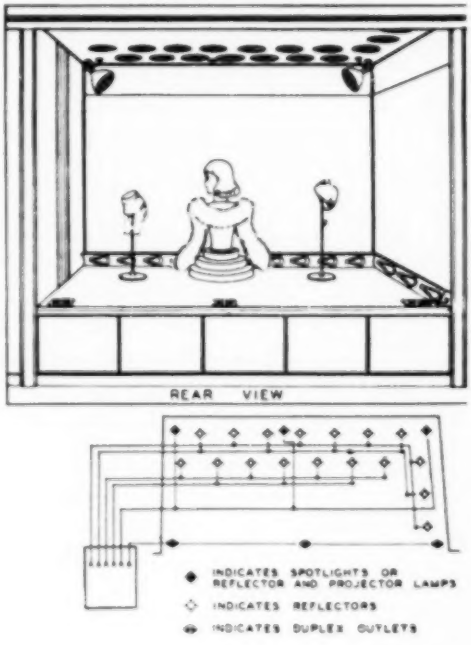
A planned arrangement of related merchandise, displayed in a well lighted window which highlights feature articles, of good contrast with the background, will be most appealing to shoppers.

Daylight reflections and night-time interferences constitute major problems of effective window display, and can be overcome only by careful design geared to the specific job. Before planning a window-lighting installation, an after-dark survey should be made of illumination interference to be encountered from nearby lighted areas or sources. On side streets, a nearby street light may be the only obstacle. On main streets, adjacent well-lighted windows, modern store fronts, super-street lighted windows may be competitive. In brightly lighted districts, attractively lighted windows, modern store fronts, super-street lighting, or a nearby theatre marquee, offer competition.

TABLE I—Effect of Colored Light on Colored Objects.

Color of Light	Actual Color of Objects	Apparent Color of Objects
Red	Black	Purple Black
Red	White	Red
Red	Red	Redder
Red	Orange	Redder Orange
Red	Yellow	Orange
Red	Dark Green	Red Black
Red	Light Green	Reddish Gray
Red	Light Blue	Violet
Red	Violet	Purple
Amber	Black	Brown Black
Amber	White	Amber
Amber	Orange	Yellow Orange
Amber	Red	Dark Orange
Amber	Yellow	Light Amber
Amber	Green	Brown Green
Amber	Dark Blue	Gray
Amber	Light Blue	Light Gray
Amber	Violet	Maroon
Green	Black	Greenish Brown
Green	White	Green
Green	Green	More Brilliant
Green	Red	Brown
Green	Orange	Yellow
Green	Indigo	Dull Green
Green	Violet	Bluish Green Brown
Blue	Black	Blue Black
Blue	White	Blue
Blue	Blue	More Vivid
Blue	Red	Violet
Blue	Orange	Brown
Blue	Yellow	Green
Blue	Green	Bluish Green
Blue	Indigo	Dark Blue Indigo
Blue	Violet	Dark Blue Violet

Figure 1. Typical window lighting layout.



MR. ZAHOUR is with Westinghouse Electric Corp., Bloomfield, N. J.

TABLE II.—Recommended Standards of Illumination for Display Windows and Display Cases.

(These values represent order of magnitude rather than exact levels)

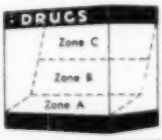
			Special Displays Inside Store		
	Show Window (Ft-c)	To Reduce Daylight Window Reflections (Ft-c)	Show Cases (Ft-c)	Light Colored (Ft-c)	Medium Colored (Ft-c)	Dark Colored (Ft-c)
Large Cities						
Brightly Lighted Districts	200	200-1000	50-100	30-50	50-100	100 or more
Secondary Business Locations	100	200-1000	50-100	30-50	50-100	100 or more
Neighborhood Stores	50	200-1000	50-100	30-50	50-100	100 or more
Medium Cities						
Brightly Lighted Districts	100	200-1000	50-100	30-50	50-100	100 or more
Neighborhood Stores	50	200-1000	50-100	30-50	50-100	100 or more
Small Cities and Towns	50	200-1000	50-100	30-50	50-100	100 or more

Similarly, a daytime survey should be part of any well planned job. Especially where the sun is bright, window-pane reflections of passing traffic or of buildings across the street may materially hide the window display and invite passersby to pause only to powder a nose or adjust a necktie.

The proper lighting design for any given show window and the selection of proper equipment to do the job, is determined by the height and depth of the window and also the nature of the display. The merchandise on display must receive the greatest amount of light. Reflectors are required which direct most of the light to the display areas, with sufficient spill light on the background to remove shadows and give a bright overall appearance.

Superimposed upon this general illumination, supplemental spotlighting is recommended to give emphasis and color. Narrow windows require concentrating reflectors or prismatic control lenses to confine the light to the display areas more efficiently. Color in show-window lighting must be used with caution and skill for full effectiveness. Colored spots or floods should be used only in conjunction with proper general illumination to accent

TABLE III.—Show Window Design Data.



Values shown in the fluorescent table were determined for the 40-watt White lamp.

Where the length of the window permits the use of the 100-watt White lamp the footcandle values should be multiplied by 1.5.

Multiply Factors for Louvers. All footcandle values calculated without louvers. If louvers are used the values in the tables should be multiplied by the corresponding "louver factor" to obtain the correct level.

LOUVER FACTORS				
	Window Depth	Zone A	Zone B	Zone C
Plastic	Narrow	90	85	80
	Medium	91	86	85
	Wide	92	91	70
Louvers	Narrow	80	70	50
	Medium	70	60	55
	Wide	60	50	40

FLUORESCENT

Window Depth (All 7' high)	No. of Rows	Zone	LENGTH OF WINDOW 4'	8'	12'
			FOOTCANDLES		
Narrow	2	A	31	40	45
		B	24	28	33
		C	45	55	65
	3	A	43	51	58
		B	27	33	38
		C	78	95	108
	4	A	56	68	78
		B	38	47	54
		C	110	180	198
Medium	2	A	34	42	47
		B	26	31	36
		C	27	33	38
	3	A	47	56	66
		B	38	48	54
		C	68	59	67
	4	A	62	75	85
		B	51	63	71
		C	66	81	92
Wide	2	A	33	39	45
		B	20	24	27
		C	14	18	19
	3	A	47	57	65
		B	32	38	44
		C	22	27	30
	4	A	60	74	84
		B	44	54	60
		C	29	35	41

INCANDESCENT

Window Depth (All 7' high)	Lamp Spacing	Zone	LENGTH OF WINDOW 4'	8'	12'
			FOOTCANDLES		
Narrow	12"	A	168	200	200
		B	64	72	72
		C	70	78	78
	14"	A	145	156	156
		B	51	54	54
		C	54	58	58
	20"	A	114	130	130
		B	39	43	43
		C	43	46	46
Medium	12"	A	179	213	225
		B	118	140	147
		C	66	79	83
	16"	A	135	157	168
		B	88	105	111
		C	50	58	62
	20"	A	112	124	135
		B	74	81	99
		C	61	66	50
Wide	12"	A	310	384	457
		B	226	272	302
		C	139	168	184
	16"	A	234	298	320
		B	168	210	224
		C	101	129	139
	20"	A	192	234	256
		B	136	166	182
		C	83	101	111

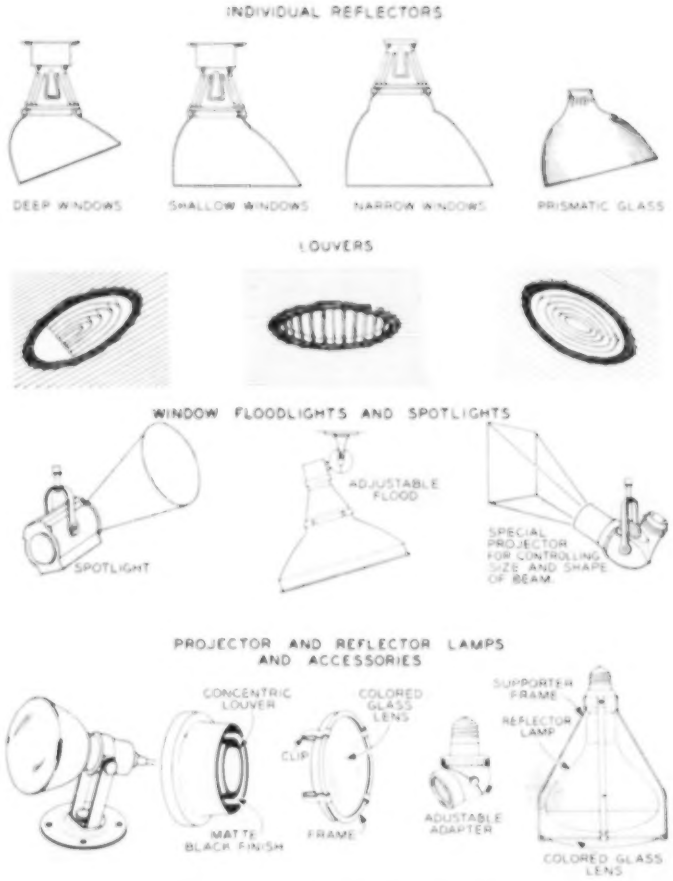


Figure 2. Show window lighting equipment.

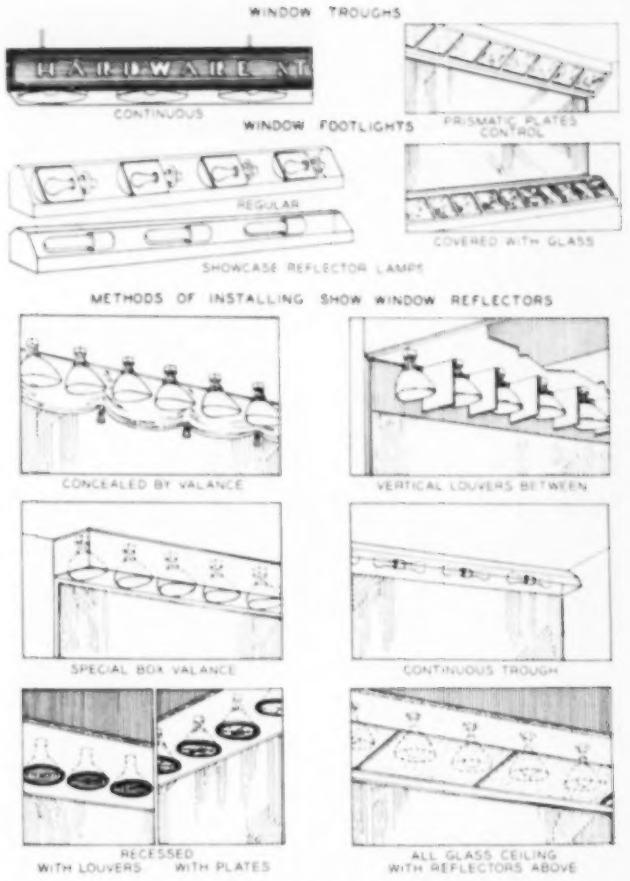


Figure 3. Show window installations.

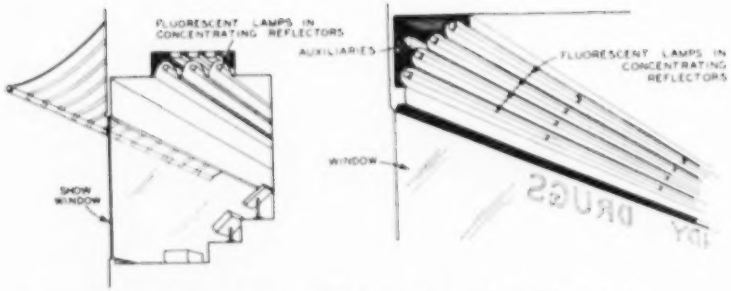


Figure 4. Show window lighting methods. Suitable only for small windows.

TABLE IV.

	Showcases							
	Incandescent Lamps with Reflector		Reflector Showcase Lamps		Lumiline Lamps		Fluorescent Lamps	
	Spacing	Watts	Spacing	Watts	Spacing	Watts	Spacing	Watts
Large Cities								
Brightly Lighted Districts	12-18"	40-60	12"	40	18"	60*		
Secondary Business Locations	12-18"	40-60	12"	25	18"	60*	18" or 36"	
Neighborhood Stores	12-18"	25	12-18"	25	18"	30	Lamps** mounted end to end in continuous rows.	
Medium Cities								
Brightly Lighted Districts	12-18"	40-60	12"	40	18"	60*		
Neighborhood Stores	12-18"	25	18"	25	18"	30		
Small Cities and Towns	12-18"	25-40	18"	25	18"	30		

*12" 40-watt Lumiline Lamps mounted end to end will produce the same level of illumination as 18" 60-watt lamps, and may be substituted in the above table.

**The 9" 6-watt and the 12" 8-watt fluorescent lamps may be used in small narrow cases where space is limited.

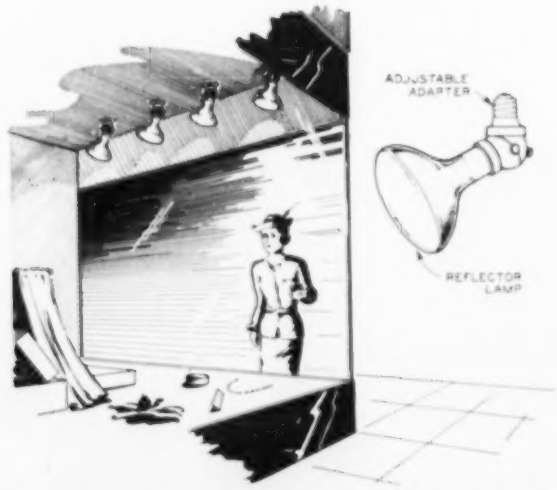


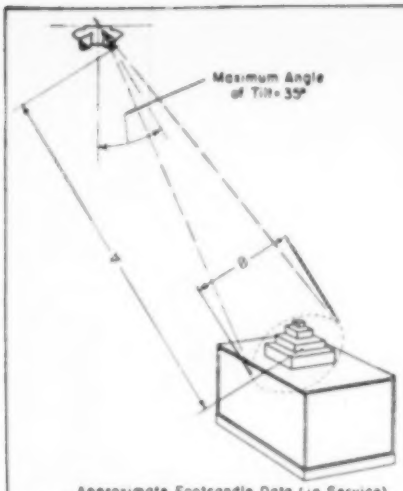
Figure 5. Use of 150-watt reflector lamps for lighting of small windows.

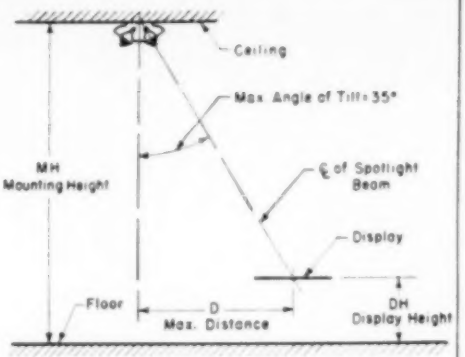
Figure 6. Lighting from under shelves.

TABLE V.

	Wall Cases and Display Shelves***							
	Incandescent Lamps with Reflector		Reflector Showcase Lamps		Lumiline Lamps		Fluorescent Lamps	
	Spacing	Watts	Spacing	Watts	Spacing	Watts	Spacing	Watts
Large Cities								
Brightly Lighted Districts	12"	100	8"	40	12" or 18"			
Secondary Business Locations	12"	60	8"	40			18", 24", 36" or 48" Lamps mounted end to end in continuous rows.	
Neighborhood Stores	12"	40	12"	40	Lamps mounted end to end in continuous rows.	40 or 60		
Medium Cities								
Brightly Lighted Districts	12"	60	8"	40				
Neighborhood Stores	12"	40	12"	40				
Small Cities and Towns	12"	25-40	12"	25-40				

***Data given apply only when lighting equipment is located at top of case and not for an individual lighting unit at each shelf. In the latter case Lumiline, Showcase Reflector Lamps, and Fluorescent Lamps should be used in accordance with data given in table for Show Cases.





Approximate Footcandle Data (in Service)

Par-38 150 Watt Projector Spot (One Lamp)					
Distance "A" from Lamp	7′	9′	11′	13′	15′
Size of Spot "B" (to 50% Max. CP)	2′	2½′	3′	3½′	4′
Footcandles at Center of Spot	148	90	60	45	32
Par-38 150 Watt Projector Flood (One Lamp)					
Distance "A" from Lamp	5′	7′	9′	11′	13′
Size of Spot "B" (to 50% of Max CP)	3½′	5′	6′	7½′	9′
Footcandles at Center of Spot	62	31	19	13	9

Maximum Horizontal Distance "D" Which Center of Spotlight Beam Can Reach

MH	DH=3′	DH=4′	DH=5′	DH=6′	DH=7′	DH=8′
10′	5′	4′	3½	3′	2′	1½
11′	5½′	5′	4′	3½′	3	2′
12′	6′	5½′	5′	4′	3½′	3′
13′	7′	6′	5½′	5′	4′	3½′
14′	7½′	7′	6′	5½′	5′	4′
15′	8½′	7½′	7′	6′	5½′	5′
16′	9′	8½′	7½′	7′	6′	5½′
17′	10′	9′	8½′	7½′	7′	6′
18′	10½′	10′	9′	8½′	7½′	7′

Figure 7. Method of computing coverage with reflector lamps.

Figure 8. Merchandiser store lighting. F. W. Woolworth Company, Mansfield, Ohio. 40-watt and 150-watt PAR-38 Spot. Spacing — variable with units located over center of counter groups. Mounting height 14 feet. Average Ft-c — 50 general, 125 featured displays.

or enliven the colors of specific merchandise. Never should colored light alone be used for window lighting. This results in distortion of the colors of displayed articles and often produces a repulsive effect. As a general rule, red and amber light emphasize articles of warm colors while blue and green light enhance merchandise of cooler shades.

For most stores, a good lighting-for-selling plan will provide 5 to 15 footcandles in the general traffic area, 30 to 50 footcandles in the selling zones, 50 to 100 footcandles in showcases, and 100 footcandles or more in feature niches.

In any well-lighted store, general overhead lighting of 5 to 15 footcandles is essential for an inviting and pleasant atmosphere. In variety stores where miscellaneous merchandise of equal price is openly displayed on closely spaced tables or counters rather than in show cases, general illumination of 50 footcandles or more is advisable. This general lighting is sometimes supplemented with concealed local spotlighting to highlight specific demonstrations or feature display.

The selling zones are extremely important, for it is there that the customer must be able to see quickly and easily all details of an article under his inspection. At least twice as much light should fall on the selling zone as in the traffic zone. Remember that showcases and wall cases need supplemental lighting, for they are miniature show windows.

Part II—Office Lighting

Two major fundamentals are involved in the design of every well planned office lighting system. *Quantity* of light for rapid seeing of specific tasks; *quality* for a comfortable visual environment.

In the average office the seeing tasks are numerous and sometimes very exacting. Eyes are used at close range for severe visual work such as reading fine print, faint typing or duplicating, poor handwriting, penciled stenographic notes, office forms, or for operating calculating devices. To differentiate these low-contrast tasks, the lighting must be adequate.

The quicker one sees, the faster he can work. Many years of investigation and study of this relationship have led to the establishment of minimum footcandle values that can be maintained economically with lighting equipment now available. With the present lamp and equipment design efficiencies, 30 to 50 footcandles can now be recommended for office lighting practice at utmost economy of operation and minimum discomfort from heat. The accompanying tabulation lists I.E.S. recommended footcandle values for various office tasks and the economics of available lighting equipment.

In the early days of office lighting when illumination levels were of the order of 5 to 10 footcandles, our only concern with quality of lighting was that

Figure 9. Showcases and wall cases illuminated from concealed light sources, make display attractive. Spots concealed in overhead equipment, accent feature items on display.

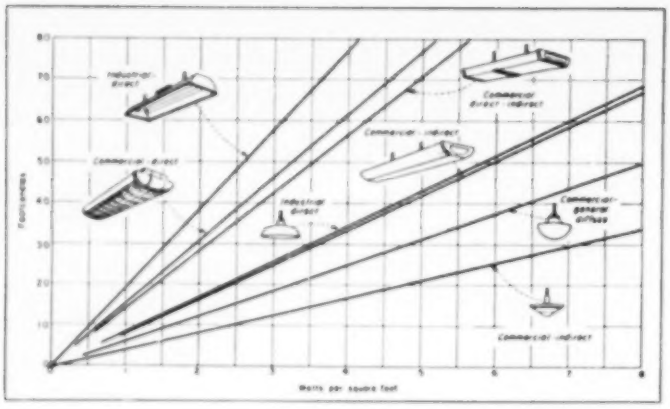


Figure 10. Wiring capacity limits illumination. The above chart is a guide in estimating the wiring capacity required for given footcandles delivered by various types of fixtures.

TABLE VI. Recommended Values of Illumination. (From I.E.S. Recommended Practice of Office Lighting—July, 1947)

Nature of Task	Footcandle Current Recommended Practice
Difficult Seeing Tasks involving	50
(a) Discrimination of fine details such as 6-5 point type	
(b) Poor contrast	
(c) Long periods of time	
Such as:	
Auditing and Accounting	
Business Machine Operation	
Transcribing and Tabulation	
Bookkeeping	
Drafting	
Designing	
Ordinary Seeing Tasks involving	30
(a) Discrimination of moderately fine detail such as 8-12 point type	
(b) Better than average contrast	
(c) Intermittent periods of time	
Such as:	
General Office Work (except for work coming under "Difficult Seeing Tasks" above	
Private Office Work	
General Correspondence	
Conference Rooms	
Active File Rooms	
Mail Rooms	
Casual Seeing Tasks such as	10
Inactive File Rooms	
Reception Rooms	
Stairways	
Washrooms and other service areas	
Simple Seeing Tasks such as	5
Hallways and Corridors	
Passageways	

of fixture brightness, and direct or reflected glare. Now, however, with present highly efficient light sources and lighting levels of 30 to 50 footcandles, the eye becomes conscious of brightness contrasts caused by variations in reflectance of wall, ceiling and furniture surfaces. Under the higher recommended levels, these surfaces virtually become effective secondary light sources which reflect light back into the room. When the contrast in brightness between various surfaces is extreme, there exists a condition which may be referred to as "contrast glare." In the general field of view, bright-

Figure 12. Left half of shiny desk top covered with dull finish, light-colored linoleum eliminates reflection seen at right.

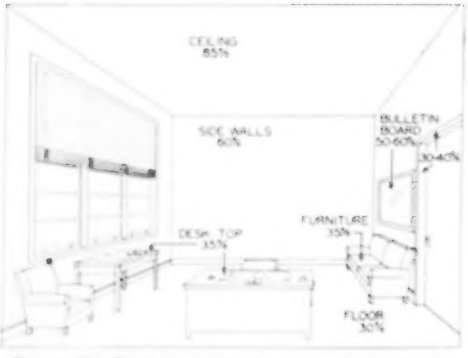


Figure 11. Brightness ratios recommended for office surfaces.

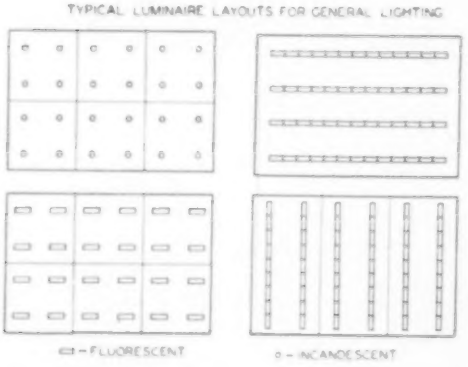


Figure 13. Typical luminaire layouts for general lighting.

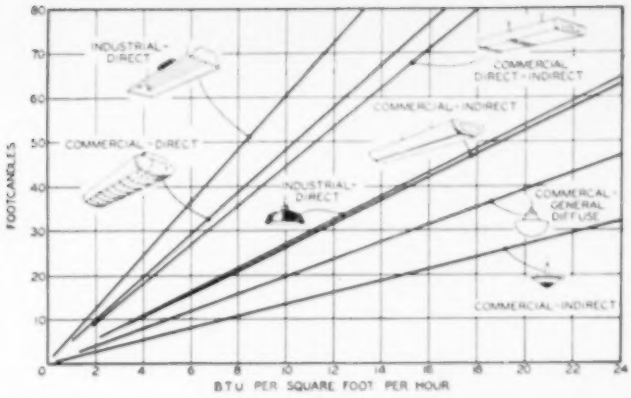


Figure 14. Heat dissipated from fluorescent and incandescent installations at given footcandle levels. These averages are extremely broad and are suitable only for rough estimation.

ness contrast becomes very annoying when performing office seeing tasks over a period of time. To correct the condition, colors for all surfaces in any office should conform to brightness ratio limits effected by reflectances indicated in the accompanying sketch (Fig. 11).

For many office workers, the desk top is virtually the entire field of view for much of the day. For eye comfort, the brightness or reflectance ratio of the work to desk top should not exceed 3 to 1. Furthermore, glass-covered or polished desk tops should be avoided since they are common sources of uncomfortable reflected glare. Desk tops may be covered with light colored, matte-finished linoleum, to correct this situation (See Fig. 12).

Since the side walls and ceiling perform as secondary light sources, these surfaces should be of a matte finish having a high reflection factor. This practice increases the utilization efficiency of any lighting system.

Figure 15. Luminous indirect system with 750-watt incandescent lamps on 9-foot centers delivers 25 to 30 footcandles.

Figure 16. Suspension-type direct-indirect system of four louver bottom fixtures each with 4-40 watt white fluorescent lamps, delivers 40 to 50 footcandles.

Luminous Ceilings — Parsons

(Continued from page 290)

Maintenance is "Good" (.50). Efficiency of luminous ceiling is .65.

$$\text{Room Coefficient} = \frac{10\,(34 + 25)}{2 \times 34 \times 25} = .34$$

Factor from Table I is 1.42 (interpolated)

$$\text{Initial Brightness of Ceiling} = \frac{50 \times 1.42}{.50} = 142 \text{ Footlamberts}$$

$$\text{Lamp } Lm \text{ Required} = \frac{142 \times 34 \times 25}{.65} = 185{,}000$$

From this figure the number of continuous rows of lamps required may be determined. Spacing of lamps within the cavity should be in accordance with Figure 4.

Supplementary Lighting — Kahler

(Continued from page 293)

However, if the light source flashes with pulsations of the same frequency as the rotating wheel, the apparent speed of the wheel can be reduced or actually stopped and then the object can be seen in detail. Special stroboscopic light sources are available for this purpose.

As the engineer understands more completely the full significance of the four fundamental factors of vision he will find leads to more logical solutions to supplementary lighting problems. Many supplementary lighting problems that have not previously been solved may require certain experimental work before the final installation is developed but this fundamental approach to the problem will serve as a guide in determining the controllable variables that influence the visibility of the task. Problems of apparent complexity may often be resolved to relatively simple solutions with readily available lighting equipment when we apply the basic principles of illuminating engineering.

Louver Systems — Potter

(Continued from page 296)

of course, is the ease of seeing it provides, the comfort attained, and the appropriateness of the environment created.

When the louver system is carried to the walls, the coefficient of utilization is less than for smaller panels as normally spaced. But this is only because of the greater amount of light falling on the walls, which in many cases will be exactly what is desired.

Generally indicative coefficients of utilization for a number of selected systems are given in Table I. They apply for a "C" room, that is, one of moderately large size. Output and utilization are favorably affected by reduced shielding angle, high reflectance of blades and cavity, by translucent blades, and by gloss or "spread"-reflecting finishes. Output gains faster than utilization because of wider spread of light.

The important gain made by using individual reflectors above lamps is apparent from the examples given. In this case gain in utilization is greater than that in output. Moderately and highly concentrating reflectors raise utilization under various conditions by as much as 45 per cent, besides reducing brightness. Shallow cavities are somewhat more efficient but may give less latitude in lamp spacing for planned brightness pattern over the grid.

Appearance Factors

Cells of small size provide widely applicable textures; with larger ones the designer is able to create a pattern appropriate to a given area. Numerous cell shapes and arrangements are available. Often a particular orientation of the lamps with respect to such cells will be advantageous. If made of low-diffusion plastic, they introduce soft highlights which impart life and interest acceptable in many installations.

Lamp spacing and height above grid are a large factor in the over-all brightness pattern. A ratio of 1.5 to 2 results in reasonable uniformity. But uniformity is not in all cases the objective. A planned variation in brightness may be less monotonous, particularly when a large area is involved. Colors may be introduced to vary the pattern either by means of sources whose combined radiation produces a satisfactory quality of illumination below, or in the form of tinted louver blades which will effect the spectral character of the illumination supplied in only a minor way.

Coves and Coffers — Jones

(Continued from page 302)

lamps and channel are mounted as in Fig. 6. For good uniformity, lamp and channel should be so positioned that the distance from the wall to the lamp center is equal to or greater than 20 per cent of distance *H*. Mounting the channel flat with the lamp on top (Fig. 7) is a less satisfactory method, since the wall near the lamp usually becomes excessively bright. White ceiling, cove interior, and backwall, are of material benefit in obtaining uni-

(Continued on next page)

formity of brightness.

The brightness of the upper wall and the ceiling near the cove largely depends on the distance of the cove from the ceiling, and on the reflectance of these surfaces. With the inside of the cove, the upper wall, and the ceiling painted white, the illumination on the wall and the ceiling near the cove is multiplied several times by the interreflections between these surfaces, the interreflections having more effect when the cove is near the ceiling. The ceiling brightness at some distance from the cove, however, is dependent more on the reflectances of the room surfaces, including the floor, than on the distance between the ceiling and the cove. Reflectors are helpful in increasing the ceiling brightness near the center of the room.

Selecting F Lamps

(Continued from page 306)

trouble. The lamp does not present a good appearance when used in bare lamp installations but is excellent for shielded equipment and its short length makes it flexible for lighting layouts.

The 90-watt lamp is low in efficiency and consequently is higher in cost than the 40-watt preheat lamp. Its main advantages are that it has a maximum light output per foot and a minimum number of lamps are required for an installation. Also it is rugged, easy to handle and has long life.

The 40-watt 48" instant start lamp with bi-pin base has a lower efficiency and consequently is high in cost. The other factors are comparable to the 40-watt preheat lamp.

The 48" T-12 slimline lamp has the lowest efficiency and therefore the highest overall cost. The luminous length is shorter than the other 48" lamps and therefore its wattage and lumen output is slightly lower. The main advantage of this lamp is the single pin base that simplifies the replacement operation particularly when compared to equipment with light duty bi-pin lampholders.

The 72" T-12 slimline lamp shows high cost because of the low efficiency. Its main advantages are easier handling and better adaptability to certain layouts than the 96" lamp.

The 96" T-8 slimline lamp operated at 200 milliamperes shows high cost because of the low lumens per foot. However, when operated at 300 milliamperes the overall cost is only slightly higher then the 96" T-12 lamp.

The 96" T-12 lamp is second in cost to the 40-watt preheat lamp and its greater diameter eliminates some of the objections to T-8 lamps.

When comparing T-12 and T-8 lamps, it is found that the T-12 diameter has many advantages that would lead one to forecast greater usefulness and better user satisfaction with the larger diameter source. The 48", 72" and 96" T-12 slimline lamps may rise to prominence in the near future, not because of individual merits, but because of their advantages as a "family" of cooperative sources.

Planned Lighting in a Men's Store

In the completely reconstructed Bohoard's Clothing Store in Pottsville, Pa., incandescent and fluorescent lighting are effectively combined to produce a well-designed planned lighting installation. The store is 75-80 feet long and 18-20 feet wide. Recessed 150-watt downlights have been mounted on 8-foot centers in line with the outside edge of the counter show cases. In service illumination on the show cases is 80-90 ft-c. Concealed single lamp 40-watt fluorescent strips above the wall cases put light on the upper walls and ceiling and reduce the brightness contrast. Lighting level on the top shelf of the wall cases is 75 ft-c, with 35 ft-c on the bottom shelf. Louvered three-light 40-watt fluorescent fixtures down the center of the room are recessed into the ceiling. Showcase merchandise is highlighted by two T-8 slimline lamps installed in each case. The general lighting provided is 56 ft-c in service. F. X. Reilly and George Rutledge of Pottsville, were the architects.

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

Summary of Action, I.E.S. Council April Meeting in Chicago

Scheduling the April meeting of the I.E.S. Council in Chicago immediately following the successful meeting of the Edison Electric Institute there, enabled a number of visiting I.E.S. members, as well as Council, to attend. Present were: C. H. Goddard, President, presiding; S. G. Hibben and Walter Sturrock, Vice-Presidents; J. C. Chambers, proxy for R. W. Stand, and Lee E. Tayler, Past-President; G. K. Hardacre, proxy for A. H. Manwaring, General Secretary; E. M. Strong, Treasurer; R. L. Biesele, Jr., Myrtle Fahsbender, W. V. C. Foulks (proxy for Duncan M. Jones), J. E. Mueller, Hoyt P. Steele, and R. R. Brady (proxy for M. N. Waterman), Directors; Norman Macdonald (proxy for G. W. Beals), Joe B. Browder, Floyd A. Covington, G. F. Dean, Edwin N. Lauth, J. S. Schuchert, and W. A. Stannard, Regional Vice-Presidents; A. D. Hinckley, Executive Secretary; C. L. Crouch, Technical Director; C. E. Ellis, Advertising and Promotion Manager; and G. Ross Henninger, Editor, I.E.S. Publications. Present also were, R. B. Brown, Jr., W. C. Brown, R. R. Cheney, R. F. Hartenstein, R. M. Hoot, E. C. Huerkamp, L. V. James, C. N. Laupp, R. R. Lusk, R. C. Paslay, C. B. Pederson, and J. F. Whitehead, Jr.

Members Emeritus

On the recommendation of the Board of Examiners, Clarence L. Law, a past-president of I.E.S., and George C. Cousins, Fellow, were elected to the grade of Member Emeritus.

Action on the election of 30 Members, 75 Associates, and 43 Student Members, brings the membership total to date to:

September 30, 1949		April 6, 1950
6883	Total Membership	7206
26	Members Emeritus	31*
44	Fellows	42
1621	Members	1614
3047	Associate Members	3261
244	Student Members	318

*Includes 7 Fellows of the Society

New Sustaining Members

A report of the Sustaining Membership Committee submitted by George J. Taylor, Chairman, was presented by the Executive Secretary, and action was taken to approve the following sustaining members:

Godfrey and Wing, Inc.
3141 Superior Ave.
Cleveland 14, Ohio
Official Representative: C. G. Wing

Kerrigan Iron Works, Inc.
1033 Herman Street
Nashville, Tennessee
Official Representative: G. E. Daniels

Quaker City Electric Mfg. Co.
1720 N. Fifth St.
Philadelphia, Pa.
Official Representative: R. Haberman

1952 Conference Confirmed

Council voted final approval on the recommendation of the National Technical Conference Committee that the 1952 Conference be held September 8-13, 1952, at the Edgewater Beach Hotel, Chicago. Plans for the 1951 Conference next year are already set for the completely air-conditioned Shoreham Hotel, Washington, D. C., August 20-25, 1951.

New Mississippi Chapter Established

Upon petition presented by J. B. Browder, Vice-President of the Southern Region, a new I.E.S. Chapter was established in Jackson, Mississippi. Mr. Browder reported that the new group, active for some time in this area, had met all of the Constitutional requirements. He reported that the new Mississippi Chapter, whose territory was released by the New Orleans Section, consisted of all of the State of Mississippi except several Gulf Coast counties.

Rocky Mountain Now a Section

Action was also taken on the petition presented by Floyd A. Covington, Vice-President of the Southwestern Region, for transfer of the Rocky Mountain Chapter to Section status. Mr. Covington noted that the Chapter amply meets the Constitutional requirements for transfer, and following presentation approval for the transfer was voted.

Possible New Regions

S. G. Hibben, Chairman of the Local Activities Committee reported that progress is being made in the analysis of the revised sub-divisions of the I.E.S. Regions in the United States. Revised boundary areas are being studied for report to Council later in the year.

You've Got a Date in Pasadena in August

Several of them, in fact!

The National Technical Conference of the Illuminating Engineering Society, which is being held at the Huntington Hotel in Pasadena on August 21 to 25 this year, is being planned with you in mind. Besides the many interesting forums and displays, tours are being arranged so that you may see the latest and best applications of lighting as applied to business, industry and the home.

Since it's always later than we think, begin now to arrange your affairs so that you can take advantage of the conference. We of the Western States will play host to the large numbers of the eastern membership who are planning to attend, so schedule your trip now, in order to take advantage of the many aspects of the conference which will interest you in your business, and at the same time, help us to demonstrate that the hospitality for which the West is famous is well deserved.

See You in Pasadena!

Street Lighting Committee Report Approved

Favorable action by Council on the report "Photographic Presentation of Street Lighting, Part I" approved this study for publication. The report was the result of work done by the Street Lighting Committee's Sub-Committee on Photographic Studies, and was presented to Council by R. M. Hoot, Chairman of the sub-committee.

Erratum

In the paper "Fading of Colored Materials by Light and Radiant Energy," by A. H. Taylor and W. G. Pracejus, March, 1950 Illuminating Engineering, the first two words of line 5, page 151, indicate that the fademometer employs "high intensity carbon arcs." This should be "enclosed carbon arcs."

Special Trains to Pasadena

J. M. Smith of Los Angeles, who is heading the committee on Transportation for the National Technical Conference of the I.E.S., to be held August 21-25 of this year at the Huntington Hotel in Pasadena, has announced that I.E.S. special cars are being discussed to bring members from the North and East to Los Angeles for the conference.

An announcement will be made later when plans are complete as to the date and time the special will be run, together with the route it will take and a schedule of connections.

Toronto Section Honors Past Chairmen

Toronto's famous castle, Casa Loma, was the setting on April 3rd of the biggest party in Toronto Section's history when nearly 250 guests gathered to honor all past chairmen of the Section at an informal dinner-ball.

Sixteen of these gentlemen, with their ladies, were piped to tables of honor in the great conservatory to the stirring strains of Scottish bagpipes by D. J. McKenzie, member of the Board of Managers and Scottish piper extraordinary, in kilt and sporran with the I.E.S. banner waving proudly from the drones.

Through bronze doors, across the marble pavement and to their tables in as stately a procession as that great hall ever saw came McKenzie with his clan, followed by a couple of hundred gay delighted people; while the classic columns and the massive stained glass dome fairly trembled to the cacophony of sound.

The Section's most recent Past-Chairman, Cecil Jones (1948-1949) and Bus Allison, next year's chairman (1950-1951) led the toasts — to his Majesty the King — to the Stars and Stripes — to all past chairmen. Guest speaker was I.E.S. Vice-President, S. G. Hibben, whose nostalgic reminiscences of lighting jobs and lighting people of days gone by, struck just the right note.

George G. Cousins, "founder" of the Section, and its first Chairman, was doubly honored — on his retirement from active business (from the Hydro Electric Power Commission of Ontario) and in appreciation of his 30 years service to the Toronto Section and the national Society.

The Past Chairmen the Toronto Section honored — those who have made it what it is today were: George G. Cousins (1921-22, 1928-30); G. R. Anderson (1922-23); W. H. Woods* (1923-25); J. T. Scott (1925-26); H. D. Burnett (1926-27); Frank T. Groome (1927-28); R. M. Love (1930-32); G. F. Mudgett (1932-34); M. B. Hastings (1934-36); J. W. Bateman (1936-38); G. Franklin Dean (1938-39); Kenneth B. Jackson (1939-40); Howard L. Wright (1940-41); P. G. Kirkpatrick (1941-42); William Dixon (1942-43); Fred C. Eley (1943-44); Frank R. Jeffrey (1944-45); R. M. Robinson (1945-46); H. F. Davidson (1946-47); J. Carl Wilson (1947-48); H. Cecil Jones (1948-49).

GEORGE G. COUSINS, (left), first Chairman of the Toronto Section is presented with an illuminated address on the occasion of his retirement, at a banquet honoring all past-chairmen of the Section. Franklin Dean (right), Vice-President of the Canadian Region, made the presentation. (Photo courtesy of *Electrical News and Engineering.*)

Deadline for Engineering Survey Extended to July 15

The closing date of the nationwide survey of selected engineering personnel sponsored by the Engineers Joint Council for the U. S. Office of Naval Research, has been advanced to July 15, 1950, it has been announced. Intended to serve as a file of key engineers working in research, development and other scientific projects who can be called in on a full or part time basis to work on the broad scientific programs of the National Military Es-

*Deceased.

tablishment, the survey was originally scheduled to close on March 15. Thus far, however, only two thirds of the 115,000 questionnaires which were sent out, have been returned by the engineers.

The questionnaires were mailed to engineers holding the full professional grade of membership in 18 national engineering societies, including I.E.S. Those which have been returned have been tabulated but a third of the forms are still hiding away on desks and in files of engineers who have much to contribute to the national defense program. The availability of such a file would insure full utilization of American engineers in tasks for which they have been trained.

Since the omission of such a large segment of the engineering profession from the proposed file will seriously limit its usefulness, the Office of Naval Research has authorized the mailing of a third reminder to delinquent engineers. Those who receive the reminder are urged to return the questionnaire so that their professional training and experience can be available. Even though an engineer may not now be engaged in research or development work, his services may be important to the country by virtue of his special training and professional recognition granted him by his professional society.

Cleveland Section Plan Clicks with Architects

The Cleveland Section of I.E.S. joined the Cleveland Chapter of the American Institute of Architects recently in a most successful cooperative effort. Under their joint sponsorship, an architectural contest was held for 43 seniors of the Western Reserve University School of Architecture, into which several rather unique features were introduced.

The contest was preceded by a five-hour "prep" course on the lighting problems likely to be encountered in the specific problem presented. The course was conducted at the General Electric Lighting Institute, Nela Park, under the direction of an Institute "faculty."

The problem itself was to design the lighting and redecorating of an existing Cleveland building, supposing it to be intended as a joint A.I.A. and I.E.S. meeting room. The room was about 100 feet by 30 feet with additional space for entrance, bar, and coat room.

The students were required to show detailed architectural and electrical plans and three perspectives of the room, as a dining-meeting room, as an exhibit room for paintings and sculpture, and as a room for parties. The lighting systems were to be done in considerable detail.

Some 36 excellent solutions were submitted. First prize ($25.00) and Certificate of Award went to Chalmer Grimm, Jr. In Mr. Grimm's prize plan, the exhibit wall was lighted by a double-trough fluorescent luminaire. The lower half was to be used for displays of drawings and sculpture. The upper section was planned as general indirect cove lighting, balanced by the double cold-cathode cove on the opposite upper wall formed by a free-form dropped ceiling. A recessed system of 31 downlights supplied the coat-room, the other exhibit wall and about ⅓ of the principal space. Four accent lights and six other ceiling floods lighted the stage and speakers' table areas.

Second prize plan, by Bert Lahm, combined indirect fluorescent coves placed crosswise with a trolley-duct. The duct ran straight along one long wall and in a meandering line near the other, circling one of the four columns. On the duct were pairs of "bullet" spot- and flood-lights to light drawings, sculpture, and a lecture platform on the corner stage.

Ray Febo's plan (which placed third) showed freer rein in form and color. His three-system plan called for: (a) 48 low-level downlights for "lectured movies," (b) 17 aimable spot- and flood-lights on stems along the west exhibit wall, ten on the east wall; and (c) 24 vari-colored indirect coves with red, green, and two white slimline tubes in each. Of the top seven selections, Mr. Febo showed the most generous use of light.

In William B. Henderson's (fourth place) plan, a system of louverall lighting predominated. The unusual system was suggested for judgments and dining meetings. It consisted of room-wide wood vanes, which covered all of the open ceiling and supplied a system of "dimming" the room. Part of the ceiling on the east side was dropped. Its contour was in a free-line extending toward the center at its widest point. The object was to "shorten" the room length. This scheme of breaking up the expanse was used in many of the rendus.

Presentation of the Award of Merit, following successful lighting architectural contest sponsored by the Cleveland Section of I.E.S. and the Cleveland Chapter of American Institute of Architects. Left to right: Robert Little, A.I.A. Program Committee; Assistant Dean Carl Droppers, Western Reserve University; Paul C. Ruth, President of Cleveland Chapter A.I.A.; Chalmer Grimm, Jr., winner of first prize; Charles L. Amick, Cleveland Section Chairman; Douglas P. Maier, Critic, School of Architecture, W.R.U.; K. A. Staley, Chairman Committee on Cooperation with Architects, Cleveland Sections. Mr. Ruth holds the prize solution, Mr. Amick, the Award of Merit.

An analysis of the 43 entries in the contest showed that:

22 used downlight; 11 used louverall (fluorescent); 2 used louverall (filament); 34 used spot- and floodlights; 25 used indirect coves and coffers; 6 used room-long troffers; 3 used semi-conventional fixtures.

The solutions all showed acceptable integration of lighting and architecture in a harmonious whole. The solutions indicated that the students appreciated the fact that most interiors require not one but many "systems" of lighting.

All 36 of the contest entries will be featured at the Great Lakes Regional Conference to be held in Buffalo, May 22-23, 1950.

Jury for the contest were Douglas Mater and Edwin F. Broggini of Western Reserve University; Anthony S. Ciresi and Carl Guenther for the A.I.A., and Paul Mehnert and Fred C. Winkler representing I.E.S. Chairman Charles L. Amick (I.E.S.) and President Paul C. Ruth (A.I.A.) presented the awards as the climax of the joint A.I.A.-I.E.S. dinner meeting held at the Allerton Hotel.

Cleveland Section is one of the few local I.E.S. groups which supports a Section Committee on Cooperation with Architects (Chairman is K. A. Staley). Their excellent liaison with Cleveland architects and architectural groups exemplifies the wisdom of this.

Lighting Courses Continue To Hold Local Interest

Courses in illumination in many Sections and Chapters are continuing as major local projects this spring, some of them being completed just in time to make way for Regional Conference programs.

In the Cleveland Section, their Education Committee, headed by John J. Neidhart as chairman, has completed (March 2 to 23) a course in Electrical Design Fundamentals for Lighting Installations. The course was open to all persons interested in getting basic information about electrical distribution. The four sessions offered were designed to familiarize the students with electrical system terms, characteristics and components, but was not intended to teach one how to wire a building. The "faculty" of qualified authorities participating were W. L. Spraggon, H. G. Barnett, H. B. Thacker, all of Westinghouse Electric Corp., Paul Mehnert, consulting engineer, and Stanley E. Strunk of the Cleveland Electric League.

The Georgia Institute of Technology at Atlanta, Ga., is currently offering an adult education class in Illumination, dealing with the theory and practical application of artificial lighting. The course is under the direction of Howard L. McKinley, Associate Professor of Electrical Engineering at Georgia Tech, who is also a member of the I.E.S. national Educational Committee.

The Chicago Lighting Institute conducted two one-day schools for lighting engineers and lighting salesmen of utility companies. Each one of the schools was offered on two different dates, enabling department heads in the utility companies to divide their lighting group, sending half on one day and the other half on another day. Commercial Lighting was conducted on March 7, and again on March 9. The course covering Industrial Lighting was held March 14, and again on March 16. Each session was conducted as full-day classes from 9 to 5 o'clock.

Lighting Clinic Now Touring U. S.

First showing of the Traveling Lighting Clinics sponsored by the General Electric Co., which are scheduled to tour the country during 1950 and 1951, was held March 7-9 at Jackson, Miss. The traveling clinic has been planned as a two-year program, designed to acquaint specific groups with the latest in lamps, lighting, and their proper application.

Specially constructed demonstration facilities, incorporating the "cream" of the exhibits at the Lighting Institute at Nela Park are features of the Clinic, and for the opening in Jackson were trucked down from Cleveland several days before. Included in the various

LIGHTING CALENDAR

Society Events

May 11-12, 1950 — Canadian Regional Conference, Mt. Royal Hotel, Montreal, Que., Canada.

May 17-19, 1950 — Midwestern Regional Conference, Milwaukee, Wisconsin.

May 18-19, 1950 — East Central Regional Conference, Warwick Hotel, Philadelphia, Pa.

May 22-23, 1950 — Great Lakes Regional Conference, Buffalo, N. Y.

June 7, 1950 — Meeting of I.E.S. National Council, New York, N. Y.

June 9, 1950 — Local Activities Conference for outgoing and incoming local officers of I.E.S., New York, N. Y.

August 21-25, 1950 — Southern California National Technical Conference, Hotel Huntington, Pasadena, Calif.

Industry Events

May 10-12, 1950 — 1950 Commercial and Industrial Electrical Exhibit, E.M.R.A., Convention Hall, Detroit, Mich.

May 10-12, 1950 — American Institute of Architects Convention, Washington, D. C.

May 15-18, 1950 — National Fire Protection Association, 54th Annual Meeting, Haddon Hall, Atlantic City, N. J.

May 29 - June 9, 1950 — Canadian International Trade Fair, Coliseum, Canadian National Exhibition Grounds, Toronto, Canada.

June 4-7, 1950 — The American Society of Refrigerating Engineers, 37th Spring Meeting, Muehlebach Hotel, Kansas City, Mo.

June 5-7, 1950 — Edison Electric Institute, 18th Annual Convention, Atlantic City, N. J.

June 12-16, 1950 — American Institute of Electrical Engineers, Summer General Meeting, Pasadena, Calif.

June 12-16, 1950 — National Association of Electrical Distributors, Atlantic City, N. J.

June 12-16, 1950 — Conference on Industrial Research, Columbia University, New York, N. Y.

June 15-19, 1950 — 60th Annual Meeting, Canadian Electrical Association, Murray Bay, Que., Canada.

June 26-30, 1950 — American Society for Testing Materials, 53rd Annual Meeting and 9th Exhibit of Testing Apparatus and Equipment, Atlantic City, N. J.

August 7-19, 1950 — First United States International Trade Fair, Chicago, Ill.

September 19-21, 1950 — The American Society of Mechanical Engineers, Fall Meeting, Hotel Sheraton, Worcester, Mass.

October 11-14, 1950 — International Association of Electrical Leagues, 15th Annual Conference, Copley Plaza, Boston, Mass.

October 16-20, 1950 — 38th National Safety Congress & Exposition of the National Safety Council, Chicago, Ill.

October 17-20, 1950 — National Electrical Contractors Association, Annual Convention, Hotel Biltmore, Los Angeles, Calif.

November 13-16, 1950 — National Electrical Manufacturers Association, Chalfonte-Haddon Hall, Atlantic City, N. J.

November 27-29, 1950 — American Standards Association, Annual Meeting, Waldorf-Astoria Hotel, New York, N. Y.

December 3-8, 1950 — The American Society of Refrigerating Engineers, 46th Annual Meeting, Hotel Commodore, New York, N. Y.

groups at whom the clinic sessions were beamed were local P.T.A. members, service clubs, commercial, industrial and school organizations. The sponsoring utility at Jackson motored as far as 85 miles away to transport special groups to the Clinic programs.

On the clinic "faculty" were representatives of the sponsoring utility company and leading specialists from Nela Park. Also present were utility executives from other sections of the country where the lighting clinics will be held.

Highlights of the three-day clinic program in Jackson included two sessions devoted to commercial lighting on the first day; office lighting and school lighting on the second day; an industrial lighting session and two home lighting programs on the final day.

Following its premiere at Jackson, the Traveling Clinic moved to Greenville, Miss., to New Orleans, to Natchez, Miss., and into Texas. Another unit of the Lighting Clinic will begin its tour in the East this spring.

Home Lighting Course Offered in Chicago

Residential Lighting has been added to the subjects covered by the outstanding courses offered by the Chicago Lighting Institute and the Section of I.E.S.

Their new home lighting course started April 12, for six sessions through May 17, with O. S. Westerberg as instructor. The course covered: Lighting Fundamentals; Light Sources and Colors; New Trends in Residential Lighting; Fixtures and Lamps; Solution of Actual Problems (Two sessions).

General Electric Planned Lighting Competition Awards Announced

Winners of 111 cash awards in the $21,000 nationwide planned lighting competition sponsored by the General Electric Lamp Department (Nela Park) were announced during the 16th annual sales conference of the Edison Electric Institute, held April 4-6 at the Edgewater Beach Hotel, Chicago.

The awards were based on the 32 outstanding planned lighting installations among the hundreds submitted. Twenty-four of the installations were in the commercial and industrial lighting classifications, and eight in the residential lighting category.

Awards of $100 each were made to individuals who have played key roles in planning, selling, supplying and installing the lighting for the best installations. Additional awards of $150 went to each person submitting reports of winning installations.

Winners of the top awards for superior residential lighting projects are:

Miss Mildred S. Ditzel, representative of the Dayton Power & Light Co., Dayton, Ohio.

Miss Dorothy Blade, of the Omaha Public Power District, Omaha, Nebraska.

W. F. Ehlers, Jr., representing the Houston Lighting and Power Co., Houston, Texas.

John P. Jett, of the Appalachian Electric Power Co., Roanoke, Va.

Miss Margaret McCloskey, representative of Consumers Power Co., Flint, Michigan.

R. A. Rhodes, West Penn Power Co., Pittsburgh, Pa.

Miss Virginia Skinner, Long Island Lighting Co., Mineola, N. Y.

Miss Verna S. Yoker, representative of the Delaware Power and Light Co., Wilmington, Delaware.

Top winners in the commercial and industrial lighting category for communities under 5000 population are:

Fillmore McPherson, Jr., district commercial manager of the Appalachian Electric Power Co., Abington, Va., on library lighting.

Arne Rintala, commercial sales representative of the Washington Water Power Co., Spokane, Wash., reporting the relighting of the Old Dominion Creamery at Colville, Washington.

C. E. Romberger, Forty Fort, Pa., commercial lighting supervisor of the Luzerne County Gas and Electric Corp., Kingston, Pa., on the Buck Mountain Lumber and Coal Co. relighting.

Gordon P. Burgess, Dayton Power and Light Co., reporting the lighting of a new building at Brookville, Ohio.

John A. Binn, St. Clair, Mich., salesman for the General Electric Supply Corp., reporting on the relighting of the Commercial and Savings Bank.

P. W. Moody, Jr., lighting design and sales representative of the Pennsylvania Power & Light Co., Harrisburg, on church lighting.

George Wellman, Chico, Calif., commercial representative of the Pacific Gas and Electric Co., on school lighting.

Leroy P. Robinson, Caro, Mich., lighting advisor for the Detroit Edison Co., on public building.

Commercial and Industrial winners in communities of 5000 to 100,000 population are:

Othmar W. Sailer, Arcadia, Calif., design engineer for C. F. Braun & Co.

Albert Klein, Jr., lighting engineer for Gulf Power Co., Pensacola, Fla.

Paul Morris, Hammond, Ind., architectural designer.

B. B. Richey, Birmingham, Alabama, manufacturers' agent.

W. A. Lowry, lighting consultant of Washington Water Power Co., Coeur d'Alene, Idaho.

Ralph L. Bvick, power engineer for the Kentucky & West Virginia Power Co., of Ashland, Ky.

Fred B. Hanson, Grand Island, Nebraska, salesman for the Graybar Electric Co.

O. William Wagner, lighting engineer of Philadelphia Electric Co., Philadelphia, Pa.

Commercial and Industrial winners in communities of more than 100,000 population are:

C. L. Daly and **C. M. J. Wood**, lighting specialists for the Pacific Gas and Electric Co., San Francisco, Calif.

George E. Shoemaker, senior lighting service representative of the Philadelphia Electric Co., Philadelphia, Pa.

Dale H. Watt, professional engineer, representing the Watt Plumbing, Air Conditioning and Electric Co., of Tulsa, Oklahoma.

F. W. Furey, White Bear Lake, Minn., chief draftsman of the Northern States Power Co. of St. Paul, Minn.

T. S. Harmon, lighting advisor of the Niagara Mohawk Power Corp., Syracuse, N. Y.

William P. Flood, engineer representing Hill and Harrigan, Consulting Engineers, of New Haven, Conn.

Clifford Miller and **John F. Gunther**, lighting engineers representing the Consolidated Edison Co. of New York, New York, N. Y.

Norman T. Kridel, representing the Rochester Gas and Electric Corp., Rochester, N. Y.

Judges of the commercial and industrial entries were: Paul C. Mehnert, Cleveland, Ohio, consulting engineer; J. Byers Hays, Cleveland architect; and Prof. E. M. Strong of Cornell University's School of Electrical Engineering. J. M. Ketch, illuminating engineer, represented General Electric as technical advisor.

In the residential lighting competition the judges were: Caroline E. Horn, Electrical Testing Laboratories Inc., New York, N. Y.; Gladys Miller, interior designer, New York; Gladys A. Branegan, director, Ohio State University's School of Home Economics, Columbus, Ohio; and Thomas Smith Kelly, lighting consultant, New York. Technical advisor to this group was Eugene W. Commery, head of the residential lighting section at Nela Park.

Cleveland Gets 1952 Lighting Exposition

Plans for the 4th International Lighting Exposition and Conference to be held in Cleveland, May 6 through 9, 1952, were officially approved by the Industrial and Commercial Light-

ing Equipment Section of the National Electrical Manufacturers Association at the semi-annual March meeting in Chicago, it has been announced by B. D. Levaur, Section Chairman. Cleveland's Municipal Auditorium, site of many national conventions, will house the Exposition and Conference.

The Planned Lighting Merit Award Competitions which have been major attractions at previous Lighting Expositions again will be held. Present plans call for an expanded competition which is expected to bring to Cleveland the finest examples of Planned Lighting ever to be exhibited. The competition will be open to architects, engineers, designers, electrical contractors and wholesalers, lighting specialists and salesmen of Utilities and Wholesalers, and to users of industrial and commercial lighting. According to the announcement, booklets containing the official rules and regulations will be available at a later date.

Indiana University Sponsors Illumination Conference

The whole problem of school illumination was approached from many angles, at the Illumination Conference held March 31 and April 1 at the School of Medicine, Indiana University, Indianapolis. Pediatricians, psychologists, psycho-physiologists, illuminating engineers, educators and many other specialists participated. Dr. D. B. Harmon of Texas, Dr. Russell Putnam of Cleveland and Dr. Le Grand H. Hardy of New York, all prominent members of I.E.S. headlined the out-of-state visitors. Several well known Indiana specialists, including architects, superintendents, and state officials also participated.

The Conference was sponsored by the Indiana State Department of Public Instruction, the Indiana University, Purdue University, and the Indianapolis School Corporation. Cooperating with the sponsors were the Indiana Chapters of the Illuminating Engineering Society, the American Institute of Architects, The Electrical Engineering Society, The Medical Society, The Society of Optometrists, The Society of Ophthalmologists, The State Teachers Association, The State School Boards Association, The State Superintendents Association, The State Trustees Association, and The Educational Buyers Association.

In addition to discussions on down-to-earth school problems, the program included a number of visits to schools featuring the latest in adequate school lighting. Under the general chairmanship of Paul W. Seagers, School Planning Consultant of Indiana University, the following discussions were presented:

"Health and Development Problems of School Children," by Dwain N. Walcher, M.D.

"Symposium, Vision, Learning and Adjustment," by LeGrand H. Hardy, M.D.; N. C. Kephart; John H. Waterman, M.D.; and Irvin M. Borish, O.D.

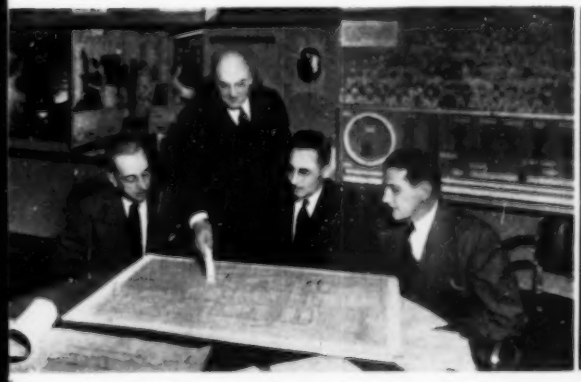
"Relationship Between Visual Environment and Health," by Dean Smiley, M.D.

Electrical Manufacturing Announces Competition for Product Design Awards

The Gage Publishing Company, New York, announces the 12th Annual Electrical Manufacturing Product Design Awards Competition, five cash awards totaling $2500 being offered for case-history stories that depict the greatest accomplishments in product design and development.

The competition is sponsored by the publishers to stimulate and encourage those engaged in the design and engineering of electrically operated products and to accord appropriate recognition for outstanding achievement. Certificates of Award will be presented to successful contestants, also to five companies designated by the Jury of Award for honorable mention.

Entries are now being accepted and the closing date for filing of manuscripts is June 30, 1950. Award winning stories will be published in the Twelfth Annual October Product Design Awards Number of Electrical Manufacturing.



Left, Judges of commercial and industrial lighting projects in the nation-wide lighting competition sponsored by General Electric Lamp Department are pictured studying one of the hundreds of entries. They are, left to right, seated, J. Byers Hays, Cleveland architect; Prof. E. M. Strong, Cornell University; and Paul C. Mehnert, Cleveland consulting engineer. Standing is J. M. Ketch, illuminating engineer, representing G. E. as technical advisor. In the photograph at right, E. D. Stryker (left), chairman of the company's Planned Lighting Awards Committee, discusses the exhibit of the winning entries with J. S. Schuchert, sales manager of the Duquesne Light Co., and chairman of the National Planned Lighting Sales Promotion Committee of the Edison Electric Institute. The 111 award winners and the 32 winning installations were identified for the first time at the E.E.I. Sales Conference in Chicago in April.

IT SEEMS TO ME

Lighting for Railway Mail Clerks

To the Editor:

Less than a week after returning for Europe, where lighting practice must advance on a first-aid basis, my attention was called to a long standing situation at home that cries for remedy.

An old friend of grade school days dropped me a note saying he had a problem and hoped that through my connection with the lighting business I could suggest some help for him. So we arranged a meeting and discussed his problem.

My friend is a railway mail clerk with many years of service. He has been having an increasing amount of trouble seeing his work, and has, within the last year, had three changes in his glasses. He has concluded now that he has had as much benefit from this source as he can expect. Away from work, normal reading gives him no trouble, so he has become convinced that his real remedy lies in the improvement of lighting in railway mail cars. From his description of the typical work situation on one of these cars, I believe any lighting man would feel sure there are opportunities for a big improvement.

A mail clerk, so my friend reports, stands in a U-shaped space virtually surrounded by use-darkened wood cases. A reflector with a filament lamp, sometimes 60, sometimes 100 watts, provides the lighting for the space. Specifications call for a range of 8 to 14 footcandles. And, in service, 80 per cent of specifications is satisfactory. Thus 11 footcandles could be the legal top level. Much work, however, is done in stations before trains are in operation. Battery supply for mail car lighting is normally much below the level provided when the train is running and the generator operating. While plug-in service in stations can materially improve the lighting, in practice, my friend reports, this is seldom offered. Lighting service is so rarely inspected, in any event, there is, for practical purposes, no consistent standard. Since there is "*some light*," it is generally assumed there is enough light.

My friend is very reluctant to concede these conditions even on a confidential basis. Railway mail clerks are not supposed to initiate any action on their own to correct working conditions. They cannot help, of course, to notice that over a number of years passenger cars have been tremendously improved by advanced lighting practice. When they read a newspaper in a modern coach they can't help feeling that the means exist for lighting their work in a fashion that would save their eyes and conserve their energy on the job. They know there are a few model mail cars, clean and trim, lighted to specifications. These are available to Washington authorities checking up on mail contracts. The mail clerks feel that such models ought to reflect the actual standard.

As a practical matter, it would seem a relatively simple undertaking to equip each mail car so the specifications could be observed at 100 per cent requirements. Since the personnel of the railway mail service has a high proportion of middle aged, long service men, the specifications seem much too low for the actual need. Vibration and noise and various other factors affecting the conditions of work in a railway mail car would seem to argue for levels high enough to compensate for the unusual obstacles to seeing. When we consider how much attention is directed in industrial practice today to problems of fatigue, poor lighting on a mail car reminds us that progress in working conditions does not advance evenly.

Perhaps the situation covered by this brief account may invite attention which the illuminating engineering profession may find useful and attractive. In Europe, where our brethren must give a lot of their skill to objectives limited by shortages and rigorous budgets, first aid remedies must probably be high in priority for some time to come. Here in the U.S.A. there is almost no situation, which imposes primitive seeing conditions on the job, which can be excused. If any considerable group of skilled workers are currently having to risk their eyesight, the I.E.S. may feel it has an obligation to investigate and make recommendations. —J. L. Tuman, *General Electric Co., Nela Park, Cleveland, Ohio.*

Color Preference Studies

To the Editor:

I would like to offer the following comments on the paper by G. B. Buck, II in the March 1950 issue, entitled "Color Preference Studies with Fluorescent Lamps."

It is possible to formulate a hypothetical "preference rule" for spectral character of light source which fits the observed fur data as well as the complexion and food data. This hypothesis is: For "appreciative" vision the spectrally preferred source is that which *exaggerates* the hue whose presence is regarded as ideal by the observer. This is not at all the same as Mr. Buck's conclusion that the light source should match the spectral reflectance of the object. Mr. Buck's rule is objective, and does not agree with his data on furs; my rule is subjective, and agrees with all of Mr. Buck's data on materials which commonly undergo subjective appraisal, such as complexions, foods and furs.

By "the hue whose presence is regarded as ideal by the observer" I mean this. We commonly prefer "peaches and cream" or rosy complexions to any other; we attribute a healthy or glowing quality to them. My hypothesis suggests, therefore, that Mr. Buck should extend his tests on complexions to include light sources with much stronger red components than are found in complexions, or in filament lamps, or soft white fluorescent lamps. Such a test might conceivably indicate a preference for a source much higher in red than the soft white lamp is, and also much higher in red than the complexion itself. I have no doubt that if we examine a group of patients suffering from Addison's Disease, which is characterized by a blue-grey cast of skin, we will find them better-looking under pink light, which does not match their own color, than under blue or white light which does. Of course, for diagnostic purposes the blue or white light would be better, but the patient's family would certainly prefer the red.

Again, in many meat display cases we see pink lamps, which exaggerate the preferred color and presumably make the merchandise look, not "natural," but "better than natural."

Finally let us consider furs. Here the customer commonly desires not

only luster and sheen, as Mr. Twichell observes, but preferably a silvery-blue or irridescent luster and sheen, regardless of the basic color of the fur. It is the business of the light source to help create or emphasize this cast, as the bluer fluorescent sources do, particularly when combined with incandescent highlighting. Most furs are sold under "daylight" fluorescent or similar bluish light sources, not to assist in discrimination, but quite the contrary, to obscure the commercially less valued hues and to exaggerate those more highly valued. Merchants generally grasp an essential truth of this sort more quickly than engineers do.

I therefore venture to suggest that extension of the tests to include a broader spectrum of light sources, and particularly redder sources, might lead to more generalized data.—SAMUEL ADAMS BOGEN, *Consultant, New York, N. Y.*

BOOKS AND PAMPHLETS

Sight Light and Efficiency by H. C. Weston, published 1949 by H. K. Lewis & Co., Ltd., London; 332 6 x 9¾ pages, 132 illustrations; available from the publisher (136 Gower Street, London, W.C.1) at 42/ (approximately $6.00) plus postage, or from C. I. Bratsford Ltd., 122 East 55th Street, New York City 22 at $9.50.

In his review of the book for a London periodical, Mr. J. N. Aldington, President of the British I.E.S. says:

"Occupational efficiency is influenced by a variety of factors not the least of which are those dependent upon the relationship between the sight of the worker, the things which he has to see and the lighting which reveals them. It is not too high praise to say that Mr. Weston has succeeded in the difficult task of revealing the inter-relationship of these factors in a manner intelligible to the layman and entrancing to the expert. He writes with the authority of one who is already known in the lighting world for his researches in occupational optics and now shows himself to be skilled in the art of making important results intelligible to a wider public."

Chapter I, "The Sense of Sight," discusses the structure of the eye and how it works.

Chapter II, "The Causes and Symptoms of Eyestrain." Here Mr. Weston states, "The first and most important environmental causes (size, poor contrast, movement, poor definition, poor legibility) and then discusses various ophthalmic defects.

,Chapter III, "Occupational Demands upon Sight," includes a classification of viewing distances; effects, examples, and methods of evaluation of visual size, contrasts, reflection factor, color and motion of visual tasks; stereopsis (three-dimensional vision) and visual skill.

Chapter III, "Occupational Demands Visual Tasks." Correction of eye defects, illumination, the provision of large-size tasks, and color symbolism are mentioned briefly, but the bulk of the chapter is devoted to (1) magnifying devices and (2) improvement of contrasts.

Chapter V, "Lighting and Visual Efficiency." Even the veteran lighting man should find in this chapter items which are either novel in themselves or discussed from a new viewpoint. Topics treated are: measurement of illumination, illumination required on work objects, individual differences in light-need, age and illumination, methods of illuminating work-objects, lighting surrounds, glare, color of light, and fluorescent lighting.

Chapter VI, "Incentive Luminance and Colour," deals with the effects of illumination and color on the worker's attitude toward his task and on the efficiency of production.

Chapter VII, "Testing Sight for Work." The author first emphasizes the importance to industry of tests of visual fitness and then describes tests for visual acuity, rate of visual perception, astigmatism, binocular muscle balance, depth perception, color vision, and observation as well as recent "multi-test visual screening devices."

Chapter VIII, "The Protection of Sight at Work," gives statistics on the number of eye injuries in industry, British statutory requirements for eye protection, causes of industrial eye injuries, explanation of the nature of such impairment and their effects on sight, first aid for eye injuries, and occupational eye diseases, concluded by an extensive section on sight-safety measures and appliances.

Author's Guide for Preparing Manuscript and Handling Proof.

Written and published (1950) by John Wiley & Sons, Inc., New York, N. Y. 80 pages; (6⅛ x 9¼); cloth bound; price $2.00. Of interest and practical use to all who seriously write manuscripts, and especially to those interested in the writing and publishing of books. The purpose of this book is two-fold: (1) to guide the author in the efficient preparation of his material, both manuscript and illustrations; and (2) to inform the author of the publishing procedure involved in the processing of his books from the time he submits his manuscript until he has the printed book in hand. Built around a simple but comprehensive flow chart (which is significant in its revelation of the number of things that do have to happen to a manuscript) practical working suggestions are given covering the best and most economical methods of handling proofs. Because of the heavy increase in printing production costs of recent years, and because of the mutual interest of author and publisher in keeping the price of a book down to a level that will appeal to a maximum audience, the book is of practical working significance to both author and publisher. Chapter headings: Preparing the Manuscript; Preparing the Illustrations; Preparing Material for Printer and Draftsman; Checking Engraver's Proof, Cut Dummy, and Galley Proof; How to Proofread; Completing Production; Formal Publication and Copyright; Preparing for Reprintings and New and Revised Editions; Appendix on Details of Editorial Style; Glossary.

Directory of Engineering Data Sources, published by Southeastern Research Institute, Inc., 5009 Peachtree Road, Atlanta, Georgia, 1948; 65 6 x 9 inch pages; price $2.50.

This booklet contains the names, addresses and information on the principle publications of (1) the Government Printing Office and federal agencies engaged in scientific research; (2) technical universities and colleges, and state agencies; (3) scientific, technical and trade associations, societies and organizations; (4) commercial publishers of books and periodicals. Over five hundred sources are listed. Bulletin is concluded by a classified section listing the sources according to sixteen major technical categories.

Painting with Light, by John Alton, Director of Photography, American Society of Cinematographers), pub-

lished by the Macmillan Company, 60 Fifth Avenue, New York, 1949; 191 7¼ x 11 inch pages, 295 illustrations; price $6.00.

Although written primarily to acquaint the public with lighting techniques used in filming motion pictures, principles which in general are equally applicable to other branches of photography, many of the ideas carry over to display and architectural lighting, and some even to illumination of homes, restaurants, etc. The book contains a wealth of information on dramatic effects produced through the use of color and highlights and shadows. Every light from the "Senior Solar Spot" to the "Inky-Dinkie," indoor and outdoor reflectors, diffusers, filters, screens and all the other gadgets used in Hollywood lighting are clearly explained and illustrated. Lamp placement and manipulation are discussed and illustrated and these stories completed with photographs of the end results. The author shows in detail the effects of light on faces and make-up, how to obtain "mood" lighting, and the importance of color even in black and white photography. Both technical and artistic aspects are included. To quote from the description on the cover flap, here is "much that will be profitable to architects and interior decorators ... to anyone, in fact, seeking to create a special effect or to put a room, an object or a person in the best light."

Applied Experimental Psychology, by Alphonse Chapanis, Wendell R. Garner and Clifford T. Morgan; published by John Wiley & Sons, Inc., New York City, 1949; 434 6 x 9 inch pages, 196 drawings; price $4.50.

This book gives basic information about man's capacities; how he sees, hears and moves, and then indicates how this information can be applied to engineering design. After an introductory discussion defining *Applied Experimental Psychology*, two chapters are devoted to statistical methods used in psychological research, seven deal with problems of sensation and perception, two with motor responses, and two with fatigue and the working environment.

Chapter IV, entitled "How We See," includes comprehensive sections on what we see, basic problems of visibility, visual acuity, eye movements, and optical illusions. This is followed by a chapter on "Instrument Dials and Legibility" and another on "Visual Displays" of various types. The final chapter contains a brief mention of light and color based on I.E.S. publications.

Experience with Reflectorized Traffic Paint by Bailey Tremper and C. E. Minor is a nine-page paper contained in the *Proceedings of the Twenty-Eighth Annual Meeting of the Highway Research Board* (1949). The State of Washington Department of Highways has found that glass beads increase the night visibility of painted traffic strips to a greater degree than other available materials as indicated below:

Type of Stripe	Visibility Range (compared to standard glass plate at 60 ft.)
	ft
1. Untreated paint film	45-80
2. Paint + natural sand	209-228
3. Paint + crushed white sand	228
4. Paint + crushed glass	210-230
5. Paint + spherical glass beads	850

For reasons of economy and wear, the most desirable maximum size of beads is that which will pass a U.S. No. 60 sieve; the index of refraction is slightly greater than 1.50. This paper describes paints with good bead-retention, laboratory tests, method of application to pavement, brightness measurements taken on four types of beaded stripes in service, and service life. Four pounds of beads per gallon of paint mixed just prior to application proved the most satisfactory mixture.

The 1949 edition of the Society of Automotive Engineers Handbook contains new specifications for liquid emergency flares, motocycle and motor driven cycle headlamps, school bus warning signal lamps, and sealed beam headlamp test specs. Revised lighting specifications include back-up lamps, direction signal lamps, electric emergency lanterns, electric headlamps for motor vehicles, electric supplementary driving lamps, electric supplementary passing lamps, fog lamps, aircraft lighting lamps, airdrome and airway lighting lamps, lamp bulbs and sealed beam units, lighting equipment for motor vehicles, sealed beam rings, stop lamps, and tail lamps.

Lighting for Sports and Recreation is a recently available bulletin issued by General Electric's Lamp Department, Nela Park, Cleveland, Ohio. Prepared by Kirk M. Reid and A. F. Nies, the 37-page bulletin comprises a guide to current recommended practices in the illumination of sports and recreational areas. Attention is given to the lighting requirements of both player and spectator. The bulletin, LD-10, is

Mission San Gabriel — Archangel

Visitors to the Southern California I.E.S. 1950 Technical Conference will have an opportunity to compare the modern lighting of the West typified by new buildings, super markets, auto service stations, drive-in banks and restaurants, movie studios, and the like with the "old" California of the days of the Indian and Franciscan Fathers who established the Mission Churches in New Mexico and California.

Within a 5-minute drive from this year's Technical Conference, at Hotel Huntington, Pasadena, is the Mission San Gabriel—Archangel in the neighboring City of San Gabriel.

Among the 21 Franciscan Missions, San Gabriel is one of the four oldest. Father Junipero Serra, first president and founder of the California Missions, dedicated it to the great Archangel and Messenger of God, St. Gabriel, from which the City gets its name.

September 8, 1771, marks the date of the founding of Mission San Gabriel and it has the distinction of being the oldest white settlement in the State north of San Diego and south of San Luis Obispo. In 1908 this Mission was turned over to the Missionary Sons of the Immaculate Heart of Mary who since then have watched over this historical landmark which has served well in the development of the West.

We are sure that many delegates to the Technical Conference will want to take the opportunity to visit and learn a little about the history of this great religious monument. The Mission is open daily from 9 a.m. to 6 p.m.

available from General Electric Co. Engineering Division, Nela Park, Cleveland 12, Ohio, at a price of 45 cents.

"The Facts of Light," a new brochure featuring information on successful Planned Lighting programs sponsored by electric companies in the commercial, residential and industrial markets, will be released to the industry by Edison Electric Institute in the near future. The brochure will present the entire group of P/L sales aids available for use in 1949-1950, and will show how electric companies have used these materials in promotional educational campaigns. It will serve as a valuable reference for industry sales executives in organizing local Planned Lighting programs.

The Seventeenth Annual Report of the Engineer's Council for Professional Development (1949) issued in February, 1950, presents 47 pages of useful and informative reading for anyone who is interested in what the engineering profession is doing to improve the competence of its members and to make engineering work more rewarding in personal satisfactions. The work of ECPD during 1948-49 is outlined in detail by its retiring president, J. W. Parker of the Detroit Edison Company. Highlights are:

1. The Pre-Engineering Inventory, a battery of tests for aptitude and achievement developed under ECPD sponsorship, was placed on a self-supporting basis and made more accessible to guidance counselors and persons desiring to be tested.

2. Accrediting of engineering curricula was continued and a program to establish minimum standards of content of engineering curriculum was initiated.

3. In the field of professional training steps were taken to establish a 7-point program directed toward extension of educational processes into the period following graduation. The plan envisages an organized program for continuing engineering education into and through the years of active employment.

4. With regard to professional recognition the Council adopted uniform nomenclature for designating the several grades of membership in constituent societies and established minimum standards for admission to the respective grades.

5. The Council's Canons of Ethics for Engineers was widely adopted by engineering organizations including the I.E.S., having an unduplicated membership of 100,000 engineers.

6. ECPD's new publication "A Professional Guide for Junior Engineers," was issued early in the year, as edited and collated by I.E.S. Director of Publications, G. R. Henninger from notes and manuscript material prepared by President W. E. Wickenden of Case Institute of Technology (deceased 1948).

An important part of the report is the listing of accredited undergraduate engineering curricula. Other features include the "Canons of Ethics for Engineers," the credo, "Faith of the Engineer," and the new feature, "What is ECPD?" which tells of the history, organization, and procedures of the ECPD as the joint agency of the national bodies of Civil, Mining and Metallurgical, Mechanical, Electrical, and Chemical Engineers, the National Council of State Boards of Engineering Examiners, the Engineering Institute of Canada, and the American Society for Engineering Education.

Copies of the 47-page 8½ by 11 inch booklet can be obtained at 50c per copy from Engineers Council for Professional Development, 29 W. 39th Street, New York, N. Y.

A 20-page illustrated booklet on **The A-B-C Plan for School Lighting** is available from the Westinghouse Electric Corp. The booklet sets forth the problems typical to most schools: (A) how much light is needed, (B) what kind of light is needed, (C) what lighting fixture will meet the requirements, (D) how many lighting fixtures will it take, (E) what lighting plan will do the best job, and (F) what other factors should be considered.

A solution to each need is suggested. Complete data are included for each type of fixture, and a number of sample school lighting layouts are illustrated.

A copy of the booklet (B-4556) may be obtained upon request to the Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.

The second edition of **Transformer Principles and Practice**, an engineering book for industry by J. B. Gibbs, has just been published (McGraw-Hill Book Company, Inc., New York). The book deals with all aspects of the construction and use of transformers, including underlying principles, applications, connection, testing, care, and economics. Price of the book is $3.50.

Review of Current Research, the 1949 edition, has recently been published by the Engineering College Research Council of the American Society for Engineering Education. The book contains a compilation of data pertinent to the projects carried on by the 82 educational institutions which hold membership in the Research Council. In each instance, the administrative policies conducting the engineering research are described; a list of the responsible personnel, research expenditures, short courses and conferences of special interest included; and titles of all engineering research studies currently active at each institution are listed. In this manner, over 4000 current college and university research projects in engineering subjects are covered (representing an expenditure of over $35,000,000). Use of the volume is facilitated by a breakdown of research projects according to the engineering departments involved, and by a complete subject index. Copies of the book, paper bound, 186 pages, are available ($1.72 postpaid) from the Engineering College Research Council, c/o F. M. Dawson, Chairman, College of Engineering, State University of Iowa, Iowa City, Iowa.

An Introduction to the Science of Artificial Lighting, by R. O. Ackerley, published by E. & F. N. Spon Ltd., London. Price 12/6.

This concise little book was written "to give an insight into the essentials" of interior illumination to architects and engineers so that they might know when to call in the lighting specialist, understand his language, "appraise the value of any advice" they might receive, and understand those factors in their own spheres of influence (*e.g.*, structure, decoration, layout) which might affect lighting design. Basic concepts of quality in lighting and the seeing process are well presented for the layman. However, the footcandle levels listed are below those recommended by the American I.E.S. The book is excellent for the beginner but might not prove much "meat" to the lighting expert. Of especial merit is Figure 6, a two-page block diagram illustrating the relationships among all the factors influencing the design of artificial illumination for any given area.

Electrical Engineers' Handbook, Volume 1: Electric Power, by Harold Pender and William A. Del Mar, published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., price $8.50. The fourth edition (1949) of this classic handbook contains a comprehensive 50-page chapter on "Lamps and Illumination" written by C. E. Weitz.

Guide to Use of Cold Cathode Fluorescent Lighting. Eight-page publication gives descriptive data and technical information on the use of standard and custom cold cathode lamps. Included are sections on installation of cold cathode and charts giving photometric data of standard lamps. The guide may be obtained by writing to the Fluorescent Lighting Association, 501 Fifth Ave., New York 17, N. Y.

Luncheon Honors Clarence C. Law, Member Emeritus

Clarence C. Law, a Past-President of I.E.S. and recently elected a Member Emeritus, was honored at a luncheon at Sherry's, New York, April 10, on the occasion of his retirement as vice-president of Consolidated Edison Inc. of New York. The luncheon was sponsored by the Electric & Gas Association, and attended by Mr. Law's numerous well-wishers in the industry and in the Society.

An additional tribute, read by James Carpenter of the Long Island Lighting Co., toastmaster, was a letter from A. D. Hinckley, I.E.S. Executive Secretary on behalf of the Society notifying Mr. Law of his recent election to Member Emeritus.

Mr. Law has been a distinguished member of the Society almost from its inception (joining in 1908) and served as President in 1923-1924.

NEW MEMBERS

At the meeting of the Council held April 6, 1950 in Chicago, the following were elected to membership:

ALAMO CHAPTER

Members:
Dallas, L. O., Central Power & Light Co., Corpus Christi, Texas
Lacey, A. L., Central Power & Light Co., Corpus Christi, Texas

Associate Member:
Graver, E. E., Westinghouse Electric Supply Co., San Antonio, Texas

BALTIMORE CHAPTER

Member:
Feige, W. C., Jr., Wm. C. Feige, Jr., Inc., Baltimore, Md.

Associate Members:
Curtis, Joseph, Westinghouse Electric Corp., Baltimore, Md.
Metze, W. J., Caspar G. Sippel, Inc., Baltimore, Md.

BRITISH COLUMBIA SECTION

Associate Members:
Brownlow, D. H., 445 Richards, Vancouver, B. C., Canada
Hollingworth, Pat, Gough & Company, Ltd., Vancouver, B. C., Canada
Merrit, R., Amalgamated Electric Corp., Ltd., Granville Island, Vancouver, B. C., Canada

CAROLINAS CHAPTER

Member:
Fields, C. W., Johannesen Electric Co., Inc., Greensboro, N. C.

Associate Member:
Stutts, J. E., Springs Cotton Mills, Lancaster, S. C.

CENTRAL NEW YORK CHAPTER

Associate Members:
Dyer, C. A., Langdon & Highes Electric Co., Inc., Utica, N. Y.
Glover, S. R., Niagara Mohawk Power Corp., Oswego, N. Y.

CHICAGO SECTION

Member:
Walsh, W. M., Efengee Electric Supply Co., Inc., Chicago, Ill.

Associate Member:
Poore, J. T., Lighting & Lamps, Chicago, Ill.

Student Members:
Campbell, University of Illinois, Urbana, Ill.
Carr, W. L., University of Illinois, Urbana, Ill.
De Vore, J. C., University of Illinois, Urbana, Ill.
Leavitt, A. F., University of Illinois, Urbana, Ill.
Simpson, J. C., University of Illinois, Urbana, Ill.
Stuesser, A. D., University of Illinois, Urbana, Ill.
Wozniak, R. E., University of Illinois, Urbana, Ill.

CLEVELAND SECTION

Member:
Dorsey, R. T., General Electric Co., Nela Park, Cleveland, Ohio
Kock, M. E., Westinghouse Electric Corp., Cleveland, Ohio
Telles, Jorge, A. Bentley & Sons Co., Toledo, Ohio

Associate Member:
Burke, R. S., Westinghouse Electric Corp., Cleveland, Ohio

Student Members:
Ake, Theodore, Jr., Case Institute of Technology, Cleveland, Ohio
Birr, R. E., The General Electric Co., Nela Park, Cleveland, Ohio
Drouillard, W. E., Case Institute of Technology, Cleveland, Ohio
Herrick, P. R., Case Institute of Technology, Cleveland, Ohio
Hilscher, R. C., Case Institute of Technology, Cleveland, Ohio
Koch, R. F., Case Institute of Technology, Cleveland, Ohio
Kyle, Charles, Case Institute of Technology, Cleveland, Ohio
Meyer, C. H., Case Institute of Technology, Cleveland, Ohio
Morris, W. H., Case Institute of Technology, Cleveland, Ohio
Moss, R. L., Case Institute of Technology, Cleveland, Ohio
Stevenson, A. H., Case Institute of Technology, Cleveland, Ohio
Wilt, L. A., Case Institute of Technology, Cleveland, Ohio
Wilt, R. G., Case Institute of Technology, Cleveland, Ohio
Winsoker, R. S., Case Institute of Technology, Cleveland, Ohio
Zoller, W. F., Case Institute of Technology, Cleveland, Ohio

CONNECTICUT SECTION

Members:
Clark, Francis, Lighting Services, Waterbury, Conn.
Cole, E. R., Hartford Electric Light Co., Hartford, Conn.
Hendricks, R. M., The Southern New England Telephone Co., New Haven, Conn.
Warnes, W. N., The Derby Gas & Electric Co., Derby, Conn.
Wilcox, L. T., The Miller Co., Meriden, Conn.

Associate Members:
Hawkins, E. A., Jr., General Electric Co., New Haven, Conn.
Sypher, H. J., Sypher Electric, Willimantic, Conn.

EASTERN PENNSYLVANIA CHAPTER

Associate Members:
Cardwell, G. P., Westinghouse Electric Supply Co., York, Pa.
Gochnauer, H. E., C. G. Gochnauer & Sons, East Petersburg, Pa.
Reidenbaugh, R. R., Roy S. Reidenbaugh Co., Lititz, Pa.

FOREIGN NON SECTION

Associate Member:
Orecchia, Giovanni, Megalux, Via Valeggio, 1, Torino, Italy

GEORGIA SECTION

Associate Member:
Calhoun, R. S., 1335 LaVista Rd., Route 2, Atlanta, Ga.

HEART OF AMERICA SECTION

Member:
Carver, L. F., General Electric Supply Corp., Kansas City, Mo.

Associate Members:
Bales, W. E., Squire Electric Co., Kansas City, Mo.
Ragsdale, J. W., Acme Products Corp., St. Joseph, Mo.
Shaw, C. F., Shaw Electric Co., Kansas City, Mo.

INLAND EMPIRE CHAPTER

Member:
Larimore, J. R., General Electric Supply Corp., Butte, Mont.

IOWA SECTION

Student Members:
Knickerbocker, J. L., Iowa State College, Ames, Iowa
Nilsson, J. W., Iowa State College, Ames, Iowa

MARITIME CHAPTER

Associate Member:
Chandler, E. S., Chappell & Co., Charlottetown, P. E. I., Canada

MOTHER LODE CHAPTER

Associate Member:
Cox, H. A., State of California, Sacramento, Calif.

MILWAUKEE CHAPTER

Student Members:
O'Brien, D. J., University of Wisconsin, Madison, Wis.
Rubsch, E. M., University of Wisconsin, Madison, Wis.
Unruth, R. R., University of Wisconsin, Madison, Wis.

NEW ENGLAND SECTION

Member:
Budd, Rowland, Stone & Webster Engineering Corp., Boston, Mass.

NEW YORK SECTION

Member Emeritus:
Law, Clarence L., 144 Harmon Ave., Pelham, N. Y.

Member:
Price, Edison, 895 2nd Ave., New York, N. Y.

Associate Members:
Eldredge, H. R., Curtis Lighting, Inc., New York, N. Y.
Sneck, H. J., Sr., Niagara Mohawk Power Corp., Glens Falls, N. Y.

Student Members:
Paris, Alan, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.
Seidman, Arthur, College of the City of New York, New York, N. Y.

NEW ORLEANS SECTION

Members:
Gensburger, J. M., New Orleans Public Service, Inc., New Orleans, La.
Morton, J. F., New Orleans Public Service, Inc., New Orleans, La.
Norwood, E. E., 201 Lamar, Jackson, Miss.

Associate Members:
Bordelon, Pat W., Salem Fluorescent Maintenance Service, New Orleans, La.
Collins, B. J., Louisiana Power & Light Co., Kenner, La.
Drummond, E. D., Drummond & Christian, Jackson, Miss.
Haynes, C. P., Watts Electric Co., Jackson, Miss.
Nothacker, S. H., Jr., New Orleans Public Service, Inc., New Orleans, La.
Shelar, D. H., Salem Fluorescent Maintenance Service, New Orleans, La.
Witcher, C. S., Louisiana Power & Light Co., Arabi, La.

Student Members:
Boykin, William, Mississippi State College, State College, Miss.
Gong, D. J., Mississippi State College, State College, Miss.
Harris, Onis O., Mississippi State College, State College, Miss.
Hunter, R. K., Mississippi State College, State College, Miss.

Continued on page 194

Doing A Store Up *Bright* With Wakefield Grenadiers and Spots

The Store: ESSERMAN'S Specialty Shop, Rome, Ga.

The Architects: POUNDSTONE, AYERS & GODWIN, Atlanta, Ga.

The Lighting Engineers: GEORGIA POWER COMPANY

When an extensive remodeling job was planned for this popular 53-year old Georgia store, the architects and the lighting engineers chose Wakefield Grenadier fluorescent Luminaires and Spots.

Result: a comfortable yet stimulating shopping environment with general illumination of about 50 footcandles; and with glare and brightness contrasts at a minimum despite lavish use of strategic spotlighting.

A shielded, louvered fluorescent luminaire with metal-framed plastic side panels, the Grenadier provides a highly efficient type of diffused light. It is designed to take 40 W or Slimline lamps, and is also available equipped with a single or double spotlight assembly permitting a 35° adjustment in any direction.

THE F. W. WAKEFIELD BRASS COMPANY • VERMILION, OHIO

All Three { ARCHITECTS ENGINEERS CONTRACTORS

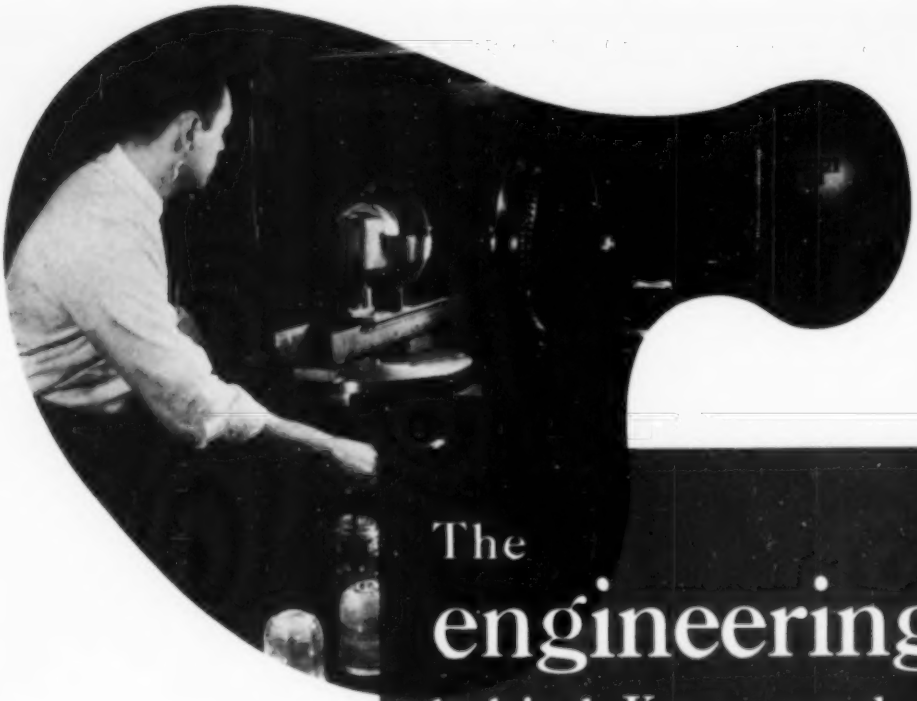
favor Wakefield Grenadiers for Store Lighting because

1. efficient type of diffused lighting
2. combination of general and spot lighting in one fixture
3. easy, quick installing; one man can do it
4. easily maintained; can be re-lamped through side or bottom and top when suspended
5. certified ballasts
6. Underwriters approved
7. fully guaranteed

Wakefield

Over-ALL Lighting

FOR SCHOOLS • OFFICES • STORES



The engineering behind Kopp products brings the results you want

KOPP specializes in lighting glassware, engineered and made to meet your particular needs. Whether your requirements are for beam control, floodlighting, signal work or color transmission, Kopp can furnish lenses, filters, cover glasses and other glassware that is correctly engineered and well made.

In our modern laboratories, research work is conducted and sample products tested. Quality control methods assure the uniformity and accuracy of Kopp products.

Write for 24-page brochure describing Kopp Glassware.

Typical Kopp Beam-Control Lenses

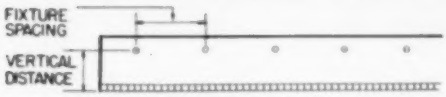
KOPP GLASS

KOPP GLASS, INC., SWISSVALE, PA.

HOW TO UTILIZE THE SYLVANIA "FLEXI-MODULE" LIGHTING SYSTEM

PART 3

Design of Evenly Lighted Ceilings



Where the Sylvania "Flexi-Module" Ceiling is to present an appearance of uniform brightness, the relationship between fixture spacing and vertical distance of fixtures above grid is of primary importance.

Fixtures are of course mounted in continuous rows for even surface brightness, and the spacing between rows is determined by the illumination intensity desired. (Recommendations for fixture spacing for various intensities are available on request from Sylvania.) For best results, the vertical distance should be at least equal to the fixture spacing.

In some instances, if bare lamp strips without reflectors are used against a white backing, sufficient light is reflected to reduce unevenness in louver brightness. In such instances, the spacing-distance ratio may be increased. For the most complete uniformity of ceiling brightness, it is recommended that the fixture rows be mounted diagonally to the grid axis. This arrangement is used in Fig. 1. Note that the individual cells are free from the inner shadows which appear in Fig. 2, when fixtures are mounted parallel to grid.

To obtain the diagonal relationship, fixtures can run parallel to walls and the grid diagonally. This arrangement offers an interesting effect—and one easily obtained because of the simplicity of cutting the grid sections to fit.

Arrangement of Fixture Rows

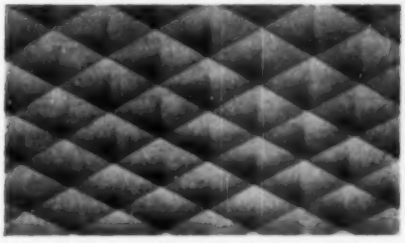


Fig. 1. Fixtures diagonal to grid axis.

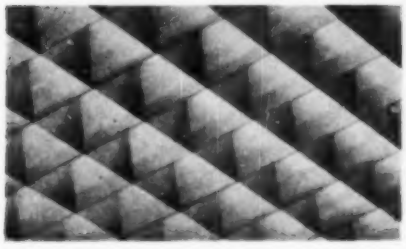
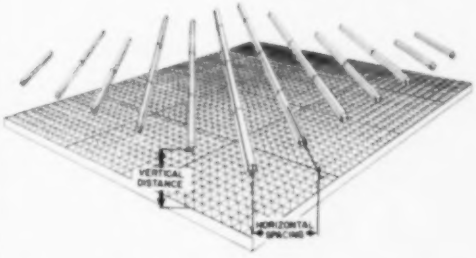


Fig. 2. Fixtures parallel to grid axis.

Distance-Spacing Ratio



If room ceiling height permits, it may be possible to increase the vertical distance of the fixtures above the grid to a figure greater than called for by the one-to-one spacing-distance ratio. As the fixtures are raised, more overlapping of light occurs at the louver grid, offsetting the decrease in illumination that might be expected under an individual fixture. Amount of light passing through the louver remains substantially unchanged, and louver appearance is improved.

Mail coupon for complete information on the Sylvania "Flexi-Module" Lighting System

Sylvania Electric Products Inc.
Advertising Dept. L-2905
1740 Broadway, New York 19, N. Y.

Gentlemen:

Please send me full information on the Sylvania "Flexi-Module" Lighting System.

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Company_____

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FLUORESCENT LAMPS, FIXTURES, WIRING DEVICES, SIGN TUBING; LIGHT BULBS; PHOTOLAMPS; RADIO TUBES; CATHODE RAY TUBES; ELECTRONIC DEVICES

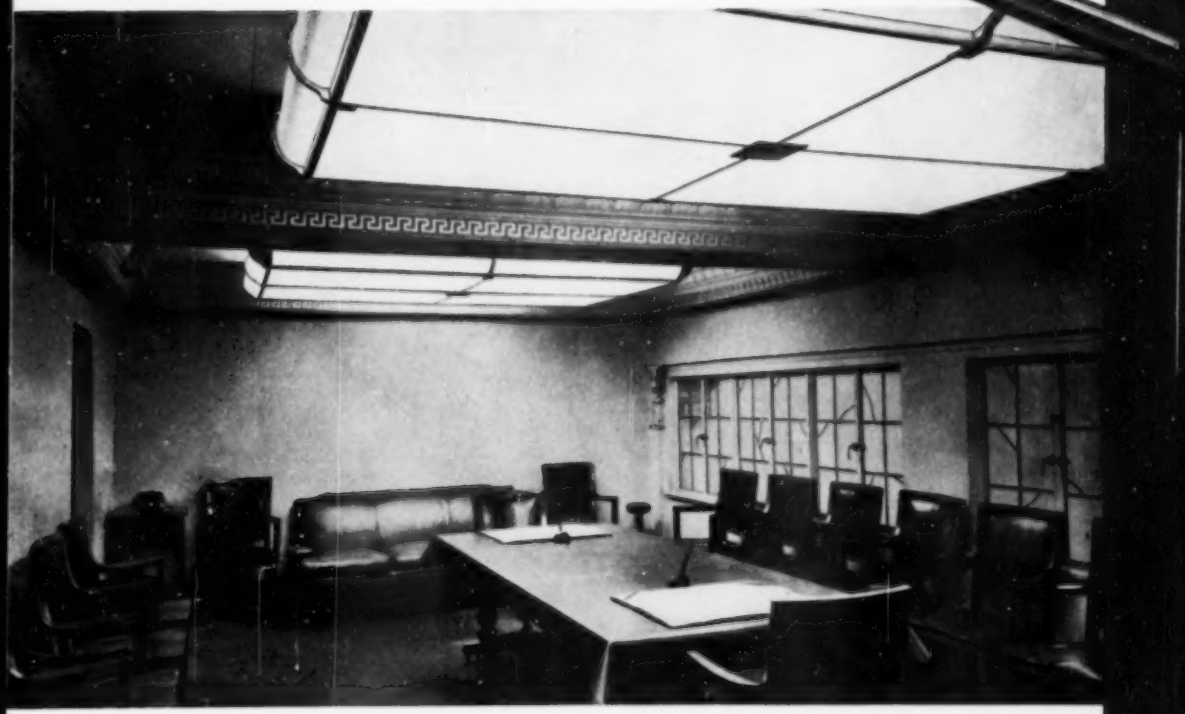
"the Board of Directors unanimously

No wonder PLEXIGLAS lighting wins approval. It provides glarefree, shadowless illumination wherever installed, from Directors' Rooms to housewives' kitchens. The full output of the lighting source is evenly diffused across the surface of this highly efficient acrylic plastic. Result: A luminous atmosphere notable for low brightness contrast and high visibility.

PLEXIGLAS aids design and installation, too. Lightness and strength mean easy erection with fewer, lighter supports. Resistance to breakage and discoloration assures low-cost maintenance. And the variety of translucency-grades in flat, patterned, or corrugated material, coupled with the ability of PLEXIGLAS to be formed readily and economically to almost any desired shape, gives almost unlimited scope to fixture design.

◀ PLEXIGLAS is used for both diffusion and reflection of light in the General Electric Company Board of Directors' Room, New York City. White translucent panels in the 9-foot-square fixtures diffuse perfectly the light from 18 Slimlines mounted only 2½" from the acrylic plastic surfaces. Lightly sanded on the outside, the panels also act as diffuse reflectors for indirect lighting from hanging fixtures that are used when the main lighting is not needed. Fixtures designed and installed by The Frink Corporation, Long Island City, New York.

approved the New PLEXIGLAS Lighting..."



▲ PLEXIGLAS ceiling lighting fixtures in the Directors' Room of Cleveland's Bank of Ohio produce an average illumination of 75 footcandles on the conference table. Each fixture measures approximately 6 x 8 feet and consists of four corrugated bottom diffusing panels with curved side panels formed from 12" strips of flat material. Ten 96" 300MA G.E. Slimline and two 40-watt fluorescent lamps (mounted at right angles at the ends of the Slimlines) illuminate each fixture. All lamps are 3000°. Fixtures installed by Bell Electric Company. Design consultants: W. E. Conley, General Electric Co.; John Liston, George S. Rider Co.; W. A. Mize, Cleveland Electric Illuminating Company.

TELL US ABOUT YOUR PROBLEM

We will be glad to work with you on specific lighting applications. Write us today. Let us show you how PLEXIGLAS can provide the best answer to your lighting problem.

PLEXIGLAS is a trade-mark, Reg. U. S. Pat. Off. and in principal foreign countries.

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Automobile Showroom • *Detroit, Mich.* **SOLD**

these 4 low-cost modules are the "building blocks" of a perfect custom-fitting lighting installation...

A 4 14-Watt T-12 15" Type F Lamps

B 32-Watt 12" Circline Lamp, and 1 PAR Spot or Flood Lamp

C 4 40-Watt T-12 48" Type F Lamps

D 4 75-Watt T-12 425 Milliamp Slimline Lamps

modules fit together perfectly end to side, end to end, side to side... to form more than 50,000 different lighting patterns...to fit any ceiling shape or size...mixing all light sources in one harmonious system... with equal brightness throughout (no dark sides or ends)...so you can put the light where it is needed!

Only MITCHELL makes MODULE

SOLD wherever you tell the module selling facts:

module is custom-fitting Here's the *new* lighting that *fits* any commercial interior to a "T". Four basic MODULE units are the "building blocks" or "dominoes" of light. They fit together easily, economically, to form over 50,000 different patterns. They custom-fit any room shape or size. They put the light *exactly* where it's needed. MODULE is the *only* lighting that *custom-fits* with standard low-cost units.

module delivers 20% MORE LIGHT Proved in actual use—MODULE delivers 20% EXTRA light per unit! Yes—the MODULE translucent plastic molded louver passes 20% MORE LIGHT. This means more light per dollar—fewer fixtures required to meet footcandle specifications. This means *more* light, *better* light at no more than the cost of ordinary fixtures.

module installations are never obsolete No MODULE lighting system is ever obsolete. Here's why: As lighting needs change, more units can be added at any time, at any point in the system—without installing a single new electric outlet box because MODULE units connect together electrically and mechanically. MODULE lighting is never "locked-in"—the "building blocks" of light simply slip into place easily and economically exactly as required.

module is newest, finest And there's nothing in lighting that will *stay* newer and finer than MODULE. Yes—a MODULE installation remains modern for years, because: it custom-fits and "grows" with every lighting need; it delivers *more* light; its appearance has an undated "always contemporary" look. No ordinary fixtures can match these MODULE advantages.

TELL THIS STORY—IT SELLS

MITCHELL module

REG. U. S. PAT. OFFICE

IF YOU HAVEN'T ALL THE **module** FACTS, WRITE TODAY

MITCHELL MANUFACTURING COMPANY
2525 N. Clybourn Avenue • Chicago 14, Illinois
In Canada: Mitchell Mfg. Co., Ltd., 11-25 Davies Ave., Toronto

How to Light the Fingers of the CURB EXCHANGE

...With Planned Lighting

Rambusch lighting engineers were given the difficult task of lighting the trading floor of the New York Curb Exchange where finger signals from telephone attendants, seated in the gallery, must be distinctly seen and correctly interpreted by their colleagues on the floor—as much as 150 feet away. Added to this the engineers had to make sure that the image of a moving ticker tape projected on a large screen would not be washed out by a splash of strong light.

The solution proved an excellent example of planned lighting where relative brightness is much more important than foot-candle intensities. Some sixty 500-watt narrow beam Rambusch Annulites were installed giving good light intensity on the trading floor without splashing bright light on the screen. Now the projected image of the moving ticker tape stands out in legible contrast against a darkened wall. At the same time, the acute task of seeing finger signals at a glance more than 150 feet away is carried out in simple order.

The members of the New York Curb Exchange now do an important job better—with good light. Rambusch lighting engineers are ready with suggestions and layouts to help make your job easier. Write today or contact the Rambusch representative nearest you for further details or a free consultation.

RAMBUSCH DESIGNERS MANUFACTURERS **40 WEST 13TH STREET, NEW YORK 11, N.Y.**

INVEST in *Sight* through BETTER *Light*

"Pittsburgh" Permaflector

LATROBE HIGH SCHOOL
Latrobe, Pennsylvania
McElroy & Fenton,
Elec. Con.

Classroom and school lighting, like all other lighting installations, must be "right" if eyesight is to be conserved and working efficiency achieved. The practical application of light is a science, but good lighting costs no more. Pittsburgh Permaflector Lighting Engineers stand ready with practical ideas and suggestions. They will work with you to help solve individual illuminating problems involving all types of applications. Send for details.

"The Monroe"
Fluorescent Luminaires

DESIGNED FOR SCHOOL and OFFICE LIGHTING

2 or 4-lamp units, using standard or slimline lamps, in a choice of steel, Alzak aluminum or framed-plastic side-panels.

WRITE FOR "PLANNED LIGHTING FOR MODERN SCHOOLS." It's the picture story of how "The Monroe" and other Pittsburgh Permaflector Equipment has been used in schools.

PITTSBURGH REFLECTOR COMPANY

411 OLIVER BUILDING • PITTSBURGH 22, PENNSYLVANIA

MANUFACTURERS OF FLUORESCENT & INCANDESCENT LIGHTING EQUIPMENT

Permaflector Lighting Engineers in All Principal Cities

PITTSBURGH PERMAFLECTOR LIGHTING EQUIPMENT IS DISTRIBUTED BY BETTER ELECTRICAL WHOLESALERS EVERYWHERE

KIRLIN

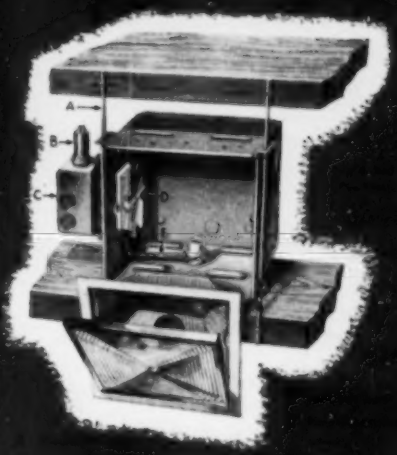
BETTER RECESSED LIGHTING

DETROIT, MICHIGAN

New!

INSTALLATION METHOD

Saves $2.00
or more on installation cost

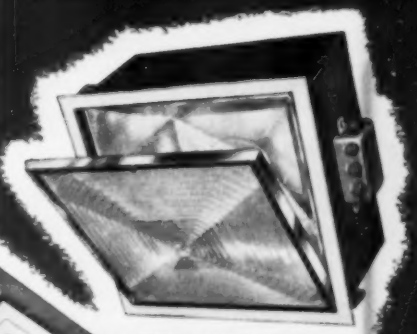


NO ASBESTOS WIRE NEEDED

Rubber-covered wire runs direct to fixture

NO CARPENTER WORK

Applies to all KIRLIN incandescent models. All parts required for installation furnished with fixtures—AF pigtails; wire-nuts; junction box; heat insulated cover; support bars and staples; tape; everything needed to the R.C. building wire.

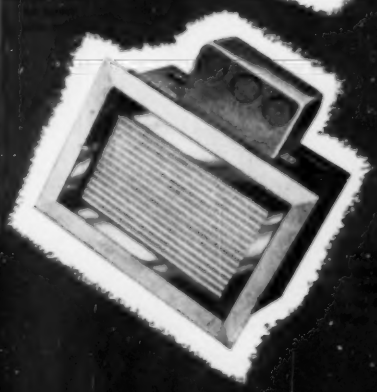


KIRLIN

Recessed Fixtures

are made in all sizes—
square or rectangular—
and in fluorescent

- Alzak GlasSurfaced Aluminum Reflectors
- Spread-type or Concentrating Lens
- Hinged Rust-resisting Doors in Diecast Frames
- Individually packed for shipping
- U.L. and IBEW LABELS
- NOTHING HANGING FROM CEILING

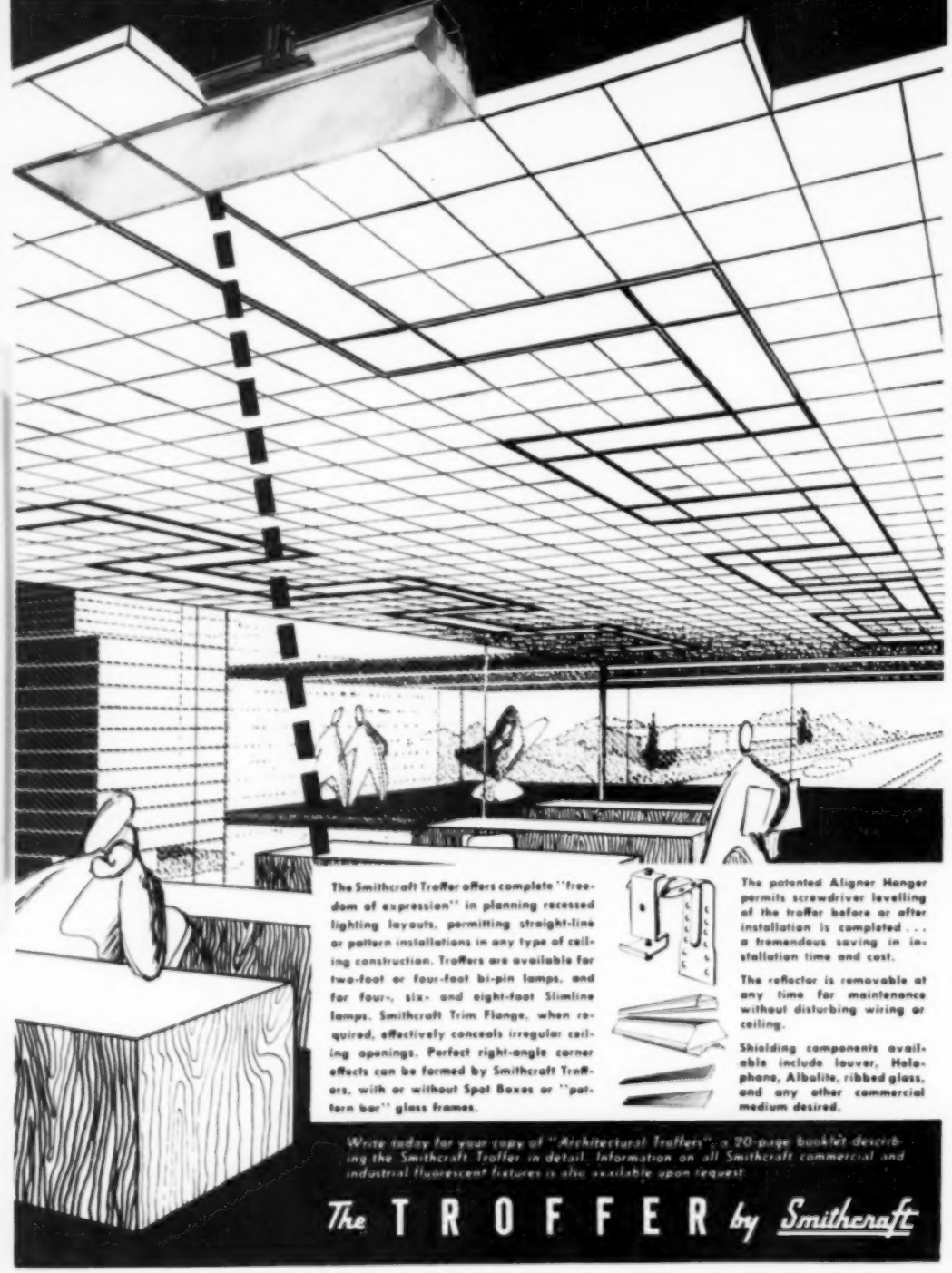


In stock at leading wholesalers everywhere.

The KIRLIN CO.

3435 E. Jefferson Avenue
Detroit 7, Michigan

Smithcraft LIGHTING DIVISION, CHELSEA 50, MASSACHUSETTS



The Smithcraft Troffer offers complete "freedom of expression" in planning recessed lighting layouts, permitting straight-line or pattern installations in any type of ceiling construction. Troffers are available for two-foot or four-foot bi-pin lamps, and for four-, six- and eight-foot Slimline lamps. Smithcraft Trim Flange, when required, effectively conceals irregular ceiling openings. Perfect right-angle corner effects can be formed by Smithcraft Troffers, with or without Spot Boxes or "pattern bar" glass frames.

The patented Aligner Hanger permits screwdriver levelling of the troffer before or after installation is completed . . . a tremendous saving in installation time and cost.

The reflector is removable at any time for maintenance without disturbing wiring or ceiling.

Shielding components available include louver, Holophane, Albolite, ribbed glass, and any other commercial medium desired.

Write today for your copy of "Architectural Troffers", a 20-page booklet describing the Smithcraft Troffer in detail. Information on all Smithcraft commercial and industrial fluorescent fixtures is also available upon request.

The TROFFER by Smithcraft

20

Years

of

ENGINEERING

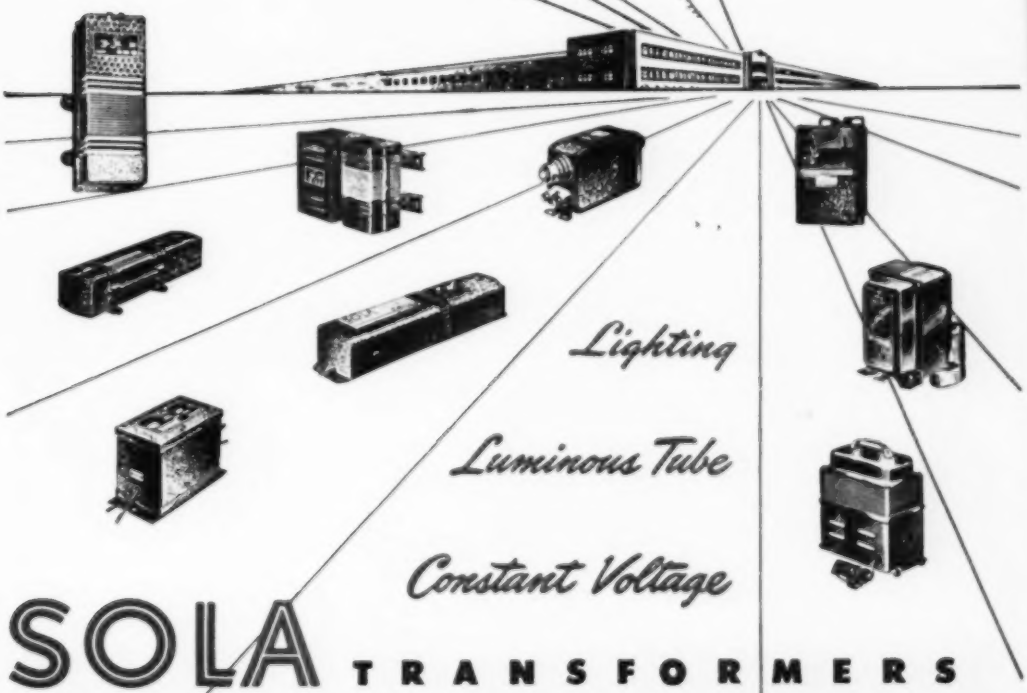
LEADERSHIP

in the

SPECIALTY

TRANSFORMER

FIELD



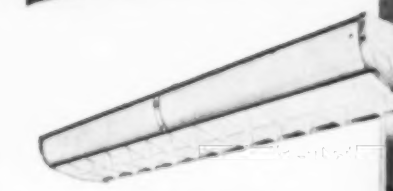
Lighting

Luminous Tube

Constant Voltage

SOLA TRANSFORMERS

NASHVILLE SCHOOLS *Choose* GIBSON



THE HIGHLANDER 5200

Beauty at low unit cost: streamlined louvers. Stamped from 20 gauge cold rolled steel or heavier. Efficiency nearly 82%, by E.T.L. analysis. Available in 430 MA 48" and 96" lengths.

THE BILTMORE 5500

85.5% efficient. Stamped from 20 gauge cold rolled steel or heavier. Hot-bonded synthetic enamel finish and only finest E.T.L. approved components used. Available in 430 MA 48" and 96" lengths.

An installation of the Gibson 5500 Biltmore in the library of West End High School, one of Nashville schools using nearly 7,000 Gibson fluorescent fixtures.

Progressive planning and investment in the health and education of our youth demands the best. Gibson features two excellent fixtures for schools. The Biltmore 5500 is the most efficient louvered fixture on the market today—85.5% by Electrical Testing Laboratory analysis.

This attractive fixture was especially designed for installation in schools and public buildings where high intensity lighting at low cost is essential. Where additional beauty is desired at low unit cost, the Highlander 5200 fills all requirements. It is finished in natural satin aluminum with white enamel louvers having translucent Polystyrene side panels.

Planned lighting with quality fixtures is the key to visual health. As a free service, lighting engineers of Gibson Manufacturing Co. will lay out lighting plans to fill the specific needs of school buildings, without cost or obligation to you. Write us today about Gibson Planned Lighting.

Newsweek

ADVERTISED IN

TIME

THE WEEKLY NEWSMAGAZINE

GIBSON *Manufacturing Co.*

1510 PIEDMONT CIRCLE, N. E. ATLANTA, GEORGIA

Corning FOTA-LITE
combines the advantages of louvers with flat glass

In many lighting installations, high level illumination and uniform brightness control are desirable, but difficult to achieve due to space limitations, cleaning difficulties and problems of decor. For lighting the Barton's Bonbonniere, Corning Fota-Lite afforded the ideal solution. With four-foot panels of Fota-Lite each with 12-40 watt 3500° lamps, excellent foot candle and brightness values are realized. Highlighting is provided by PYREX brand Lenslites illuminated by 150 watt lamps. Every light fixture is recessed. Cleaning is greatly simplified.

FOTA-LITE is a revolutionary lighting medium. Without bulky, hard-to-clean materials, light distribution is controlled by louvers photographically sealed in a thin panel of glass. Fixtures can be made shallow and dust-tight. Initial efficiency remains unimpaired.

The cell size of Fota-Lite louvers is many times smaller than in conventional louvering materials. This gives it the appearance of an opal diffusing glass. However, vertical light is unrestricted by the clear sections and surface brightness is reduced by the 45° cut-off of the diffusing louvers.

The versatility of Fota-Lite gives it an unusually wide range of application. It will pay you to investigate. Send for a sample demonstration card today.

◁ *Barton's Bonbonniere, New York City*

Designer: Hans Weiss and William Basser, New York City
Fixture Manufacturer: Neo-Ray Products, Inc., New York City
Electrical Contractor: Bigman Brothers, Brooklyn, N. Y.
Glass: Corning Fota-Lite (note photo below) and Pyrex brand Lenslites

CORNING GLASS WORKS
CORNING, NEW YORK
Corning means research in Glass

FOR EFFICIENT, ATTRACTIVE LIGHTING . . .
CORNING ALBA-LITE for diffusion of fluorescent light . . . CORNING FOTA-LITE for high level illumination . . . CORNING brand LENS PANELS and PYREX brand LENSLITES for prismatic light control

***FREE*—FOTA-LITE sample on request.**

CORNING GLASS WORKS, Dept. IE-5, Corning, N. Y.
Please send me your FOTA-LITE demonstration card showing how FOTA-LITE diffuses and cuts off light at 45°

Name _____ Title _____
Company _____
Address _____
City _____ Zone _____ State _____

Typical examples of winning installations

32 installations win General Electric planned lighting awards!

ALL BRANCHES OF LIGHTING INDUSTRY REPRESENTED! Contestants in General Electric's Planned Lighting Competition included utility company representatives, contractors, builders, dealers, wholesalers, lighting engineers, and architects. A total of 247 planned lighting installations were entered, and every part of the country was represented.

109 PRIZES! There were 32 winning installations. Each of the 109 persons who played a part in the winning installations received a $100 cash award. An additional $150 was presented to the person who submitted the report.

CREATES WIDESPREAD INTEREST! The large number and high quality of the entries indicate that the competition focused widespread interest on planned lighting. And the winning installations provide examples across the country of better residential, commercial, and industrial lighting.

THIS PLANNED LIGHTING COMPETITION is one of the many ways in which General Electric supports the Planned Lighting Program.

If you would like to have a complete list of the award-winning installations, including those in your area, write the General Electric Co., Lamp Dept., Nela Park, Div. 166-IE5, Cleveland 12, Ohio.

LAMPS

GENERAL ELECTRIC

Continued from page 338

Lyles, W. S., Mississippi State College, State College, Miss.
Regan, Murray, Mississippi State College, State College, Miss.
Smith, W. A., Mississippi State College, State College, Miss.
Watrous, G. S., Jr., Mississippi State College, State College, Miss.

NORTHERN CALIFORNIA SECTION

Member:
Johnson, S. E., 610 16th St., Oakland, Calif.

Associate Member:
Herbert, M. G., Millard & Hagerty, San Jose, Calif.

Student Members:
Beaudet, J. A., University of California, Berkeley, Calif.
Bloss, Stanley, Stanford University, Palo Alto, Calif.
Caldwell, J. B., Jr., Stanford University, Stanford, Calif.
Marshall, E. L., Stanford University, Stanford, Calif.
Sander, W. H., Leland Stanford Junior University, Stanford, Calif.
Watermeyer, Erwin, Stanford University, Stanford, Calif.

OHIO VALLEY SECTION

Associate Member:
Misrach, S. G., Stanley Electric Supply Co., Inc., Dayton, Ohio

PITTSBURGH SECTION

Associate Member:
Rhodes, H. A., West Penn Power Co., Greensburg, Pa.

PHILADELPHIA SECTION

Members:
Bleeker, A. L., Philadelphia Electric Co., Philadelphia, Pa.
Tynan, J. J., Atlantic City Electric Co., Atlantic City, N. J.

Associate Members:
Adler, Jack, 431 Champlost Ave., Philadelphia, Pa.
Grossman, J. A., Grossman Electric Supply Co., Wilmington, Del.

QUEBEC CHAPTER

Associate Members:
Beland, Paul, 2490 Parc Falaise, Sillery, Que., Canada
Dorais, A. W., Quebec Power Co., Montmagny, Que., Canada
Frenette, Emile, 71 St. Lawrence St., Quebec, Que., Canada
Goulet, Jacques, 253½ Napoleon, Quebec, Que., Canada
Grenier, Albert, Riviere Bleue, Co. Temiscouata, Que., Canada
Tanguay, Rosario, Ste. Justine (Bureau Langevin), Co., Dorchester, Que., Canada

ROCHESTER CHAPTER

Associate Member:
Thulane, C. E., Monroe Electrical Products Co., Rochester, N. Y.

ROCKY MOUNTAIN CHAPTER

Member:
Vanneman, J. L., General Electric Supply Corp., Denver, Colo.

Associate Members:
Berg, S. L., Bureau of Reclamation, Denver, Colo.
Dunn, F. A., General Electric Supply Corp., Albuquerque, N. M.
Leasure, G. A., Bureau of Reclamation, Denver, Colo.
Reed, L. S., L. S. Reed & Co., Denver, Colo.
Roughton, B. G., General Electric Supply Corp., Albuquerque, N. M.
Stephan, Algird, Acme Mfg. & Supply Co., Denver, Colo.
Wells, C. H., Public Service Co. of Colorado, Brighton, Colo.

ST. LOUIS SECTION

Members:
Welch, R. J., R. J. Welch Co., St. Louis, Mo.
Cline, F. C., Westinghouse Electric Corp., St. Louis, Mo.
Sachs, L. S., S. C. Sachs Co., St. Louis, Mo.
Stuhlmann, E. W., Jr., Union Electric Co. of Missouri, St. Louis, Mo.

SOUTHERN CALIFORNIA SECTION

Members:
Booth, A. E., 4124 Beverly Blvd., Los Angeles, Calif.
Goodlaw, Edward, Dr., 219 W. 7th St., Los Angeles, Calif.

Continued on page 22A

WHITER THAN WHITE

ABOLITE
DUO-MOVE
SYSTEM

The formula for Good Lighting is the combination of proper equipment and simple methods of maintenance. The Abolite Duo-Move System encourages regular cleaning habits because Duo-Move units can be cleaned and relamped quickly and safely without using clumsy ladders. Merely a twist of the wrist—reflector and lamp assembly can be removed and serviced—another turn and it's back in position . . . no interruption to workers . . . no lost time. The Abolite Duo-Move System guarantees maximum illumination with minimum service expense. Write for the Duo-Move story today!

THE JONES METAL PRODUCTS CO.
West Lafayette, O.

WHITER THAN WHITE
ABOLITE Lighting

New Graduates Available . . .

Graduating from University of Illinois, B.S., E.E., illumination option, June 1950. Would prefer work in sales and lighting design layout. Available June 20. Roy Edward Bevan, 106 N. Vine, Urbana, Ill.

February 1950 graduate, Purdue University. Now located in Little Rock, Ark. as exclusive agent of industrial chemical manufacturer, distributing maintenance chemicals to Arkansas industry. Have in mind for near future addition of industrial luminaires to my sales organization. Any help or information you can give me that will help establish this line will be very greatly appreciated. Robert L. Brickhouse, Arkansas Protective Chemicals Co., 1223 W. Capitol Ave., Little Rock, Ark.

B.S., E.E., University of Illinois. Graduate June 16, 1950. Available June 20. Tau Beta Pi. Three years Army service. Married. Age 25. Desires work in illumination application engineering and sales. Prefer Midwest. Donald Bringman, 311 W. Springfield, Champaign, Ill.

Completing work for B.S. degree in electrical engineering June 1950. Desire position with public utility. Available July 1950. M. Milton Buzan, 705 S. Gregory Pl., Urbana, Ill.

Bachelor in E.E. June 1950. Available August. Wants job in illumination layout or research in Ohio, Indiana, Illinois, Michigan, Wisconsin, California or Hawaii. Albert S. C. Chong, University of Dayton, Box 327, Dayton, Ohio.

Will graduate August 1950 with E.E. degree. Available August 23, 1950. Student member I.E.S. Age 27. Single. Desires position in illumination field. Some experience in electrical construction and maintenance and electronics. Will locate practically anywhere in states. Alphonse A. Cygal, 3167 N. 34th St., Milwaukee 16, Wis.

E.E., January 1950, top 25%. Eta Kappa Nu. Age 24. Single. Some experience in personnel quality control; desires position with future doing lighting design and installation; lamp or luminaire design and development. Will relocate near graduate school. Available New York City for interview. Jerome L. Deitz, 760 Albany Ave., Brooklyn 3, N. Y.

Will obtain B.S. in E.E., illumination option, August 1950. Would like job at that time in any phase of illumination, preferably layout design or sales and application. Prefer South, but will take position elsewhere. Kendall C. Dempsey, Box 963, State College, Miss.

Optometry College graduate, June 1950; member I.E.S., O.S.A., and author of several scientific papers, desires connection with consulting engineer in any progressive capacity (grades, ability, interest all above average). George Elmstrom, 415 E. Adams Blvd., Los Angeles 11, Calif.

Graduating University of Wisconsin June 17, 1950, B.S. in E.E. Age 22. Desires sales or field engineering in illumination field. Prefer Midwest, but will locate elsewhere. Willing to travel. Own car. Available June 1950. Harold C. Fisher, 1630 17th Ave., South Milwaukee, Wis.

The illumination industry is young and growing. I am young and want to grow with it. Will accept any position relative to engineering or drafting. Location no object. February graduate, University of Illinois, B.S. in E.E. Power option. Available immediately. David Ford, Jr., 817 Ames, Hammond, Ind.

B.E.E. June 1950 graduate. Top 10% of class. Single. Veteran. Age 25. Electives in illumination. Some experience in wiring and illumination layout. Prefer trainee position in lighting layout or production. Locate eastern half U. S. Stanley Grosser, 526 Dahill Rd., Brooklyn 18, N. Y.

Will graduate May 1950 with B.A.Sc. in electrical engineering from University of British Columbia. Age 25. Married, no children. Interested in both electrical and illuminating engineering. Location of employment not important. N. L. Harvey, 3656 W. 15th Ave., Vancouver, B. C., Can.

Graduate June 1950 E.E. Cornell. Age 23. Single. Own car. Experience includes assistant instructor illuminating engineering, research in colorimetry, lighting design projects. Full resume on request. Desire work in lighting design or sales. Available after June 15. Will relocate. Warren Hastings, White Plains Rd., Tarrytown, N. Y.

B.S. in E.E. June 18, 1950, University of Illinois. Available June 19, 1950. Special training in illuminating engineering. Particularly interested in lighting sales engineering and lighting design. Willard E. Hayes, 715 Montgomery St., Staunton, Ill.

B.S. in E.E., illumination option, May 1950, Mississippi State College. Desires work in illumination field, preferably layout design or application and sales. Available June 1, 1950. Prefer South, but will take job elsewhere. Lawrence H. Hickman, Box 349, State College, Miss.

Electrical engineer, June graduate, B.S., University of Dayton. Experience in engineering field. Desires illuminating engineering work. Middle West preferred, but not necessary. Available after June 5. Will mail personal resume upon request. Age 23. Richard L. Hine, 1340 Concord Ave., N. E., Massillon, Ohio.

Junior engineer, B.E.E., Cooper Union, 1949. Age 27. One year radio test, one year drafting, three months lighting design experience. Studying for M.S.E.E. evenings. Looking hard for real job in design, development or research. New York City preferred. Sheldon Katz, 600 Pine St., Brooklyn 8, N. Y.

Electrical engineer, June 1950 graduate, illumination electives. Desire starting position in design or production. Age 32. Married. Will locate anywhere. Available New York City for interview. Jack Knoll, 1476 Shakespeare Ave., Bronx 52, N. Y. LUdlow 7-1932.

E.E. 1948, Bus. and Eng. Admin., 1949, M.I.T. Available August 1950. Familiar with practical commercial lighting. Prefer sales engineering or sales managership. Prefer New York City area, but will consider others. Paul R. Krasner, 300 Ocean Parkway, Brooklyn, N. Y.

B.S. Antioch College, June 1950. E.E. major. Wide range of work experience, including General Electric engineers' training program, and theater lighting; interested in illumination and creative lighting in New York City; excellent employers' references. Available now. Joan L. Levine, 40 W. 84th St., New York 24, N. Y. ENdicott 2-8211.

Graduate August 1950 C.C.N.Y. Available after August 15. Prefer location within 50 miles of graduate school anywhere in U. S. or possessions. Tau Beta Pi and Eta Kappa Nu. Martin Levine, 919 Dumont Ave., Brooklyn 7, N. Y.

B.S. in E.E., illumination option, University of California, June 1950. Desire position in Los Angeles or San Francisco areas, but will consider others. No experience, but eager. Age 23. Single. Eta Kappa Nu and Tau Beta Pi. Mihran Le Von Jr., 2428 Channing Way, Berkeley 4, Calif.

Electrical engineer graduating Marquette University, June 1950, B.E.E. degree. Desire work in lighting and power field, preferably in East. Available June 15. Hold Marine Engineers Steam and Diesel License and familiar with steam power plants and illuminating layout requirements. Bernard M. Lyons, 110 Suydam St., New Brunswick, N. J.

Scholarship winner, Chicago Section I.E.S. Illuminating engineering graduate University of Illinois, June 1950, desires position in lighting field doing sales and/or layout work. Age 22. Single. Have ability—desire opportunity. Will locate anywhere. Gerald Marks, 303 E. Green St., Champaign, Ill.

E.E. graduate presently doing research in illumination at University of California is much interested in lighting design and installation leading to consultant. Design and sales experience abroad with Pacific Gas & Electric Co. and Westinghouse Electric Corp. Available end of June. R. Marsheimer, 1681 31st Ave., San Francisco 22, Calif.

Graduate July 15, 1950 with B.S. in E.E., illumination option. Age 25. Married. Desire work in interior and/or exterior layout design and application or sales. Any location, South preferred. Edra L. Maxey, Jr., Box 631, State College, Miss.

University of Cincinnati, E.E. graduate June 9, 1950. Student member I.E.S., A.I.E.E., O.S.P.E. Cooperative work experience making street lighting survey for large Midwestern power company. Prefer Midwest or West location. Available June 15. Charles McCann, Jr., Room 12, Dormitory D, Campus Station, Cincinnati 21, Ohio.

B.A.Sc. University of Toronto in engineering physics with 20 semester hours specialization in photometry and illumination design. Desires position leading to lighting design work. In Toronto until graduation June 2, available September 15, 1950. Prefer Canadian location. Age 30. Married. Veteran. L. V. Mills, 50 Indian Trail, Toronto, Ont., Can.

E.E. graduate May 1950, McGill University. Two summers experience with consulting engineer in lighting and industrial electrical design. Willing to work anywhere. Age 27. G. E. Mulvey, 5901 Hutchison St., Montreal, Que., Can.

M.S. University of Illinois. Graduate June 1950. B.S. Case Institute of Technology. Available July 1. Desires work in application of lighting and design of lighting installations. Any location. Anson Henry Russell, 506 E. Springfield Ave., Champaign, Ill.

Holder of B. Architecture, University of Cairo, 1945; M.S., University of Michigan, 1947; Ph.D., Cornell University, 1949; now available for a representation to any electrical company having work in Egypt. Dr. Mohamed Sabah, 2 Mohamed Pasha Sidky St. Midan El Falaki, Cairo, Egypt.

Will graduate from University of Illinois June 1950, B.S., in E.E. Desire employment in illumination design, development, or similar field. Available July 15. Prefer Midwestern location. Robert L. Sandburg, 1473 Monroe St., Galesburg, Ill.

Graduate June 1950, B.S. in E.E., University of Cincinnati. Vice-Chairman student branch I.E.S., member student branch A.I.E.E. Prefer application and sales in illumination or field service in power and industrial electronic lines. No preferred location. C. J. Schaefer, 2144 Queen City Ave., Cincinnati 14, Ohio.

Is there a company that does not require 5 years experience? University of Cincinnati graduate, 1949, B.E.E., looking for a better engineering or sales position. Drafting-design experience, presently employed in electrical sales, Cincinnati locale. Theodore A. Scherpenberg, 4319 Sullivan Ave., St. Bernard, Ohio.

Hope to get married. Need job. Not too particular about type of work except that it be with some application of lighting. Age 23. Will receive B.S. in E.E. with illumination option from University of California in June. Norman Schiewe, 458 Edinburgh St., San Francisco 12, Calif.

Can't get work without experience; can't get experience without work. Don't answer unless your position has possibilities for advancement. Graduating June 9 with B.S., E.E., from University of Cincinnati Cooperative Course. Married. Veteran. Will re-locate anywhere in States. Gordon J. Schilmeister, 578 E. Mitchell Ave., Cincinnati 29, Ohio.

M.S. in Engineering, Syracuse, September 1950; B.S. in Engineering, University of Buffalo, February 1950. Available September. Prefer location in Niagara Falls or western N. Y. State. Industrial and illumination major. Gordon Thomas Shahin, 1101 Niagara St., Niagara Falls, N. Y.

Desire position as junior illuminating or construction engineer. Available immediately. Locate anywhere in U. S. E.E. February 1950, C.C.N.Y. Two years naval experience in airborne electronic equipment. Gerard Charles Sharpe, 121-12 Atlantic Ave., Richmond Hill 19, N. Y.

May 1950 graduate, B.S. in E.E., illumination option, Mississippi State College, desires work in illuminating engineering. Available June 1950. Prefer location in South, but will work elsewhere. Robert T. Sloan, Abbeville, Miss.

Graduate electrical engineer (illumination option) wants position in sales or application. B.S. May 29, 1950. Available June 1, 1950. Prefer permanent location in South. E. Mark Smith, Box 588, State College, Miss.

June graduate, University of Cincinnati, with E.E. degree. Seeking position in lighting field (development or application). Have had illumination course. Power major but have considerable electronic background. Will locate anywhere. Richard K. Stone, 1439 N. Fort Thomas Ave., Fort Thomas, Ky.

E.E. graduate student, illumination major, mathematics, mechanical engineering minor, M.S. degree June 1950, Iowa State College, where full time instructor three years, desires work in illumination field. Age 24. Two summers with architectural firm; one summer junior engineer with public utility. David A. Tuntjes, E.E. Dept., Iowa State College, Ames, Iowa.

Industrial Designer. Member I.E.S., A.A.A.S. Six years advertising experience. Three years studying industrial design at Illinois Institute of Technology. Seeks summer employment (available June 1, any location), with view toward permanent position in spring when receive A.B. Has designed and built lamps, displays, plastics, exhibition space, panel construction, etc. Budd B. Turchin, 339 S. California Ave., Chicago 12, Ill.

E.E. (Illumination) graduate desires position in illumination application, photometric lab, research, sales, or design. Will consider any location with reasonable offer for a few years but prefer the Mid South. Available after graduation July 1. Single. Age 23. Henry A. Waring, Jr., Box 1179, State College, Miss.

Will graduate in E.E., illumination option, B.S. July 1950. Desire position in illumination field, prefer interior and/or exterior layout design or sales. Will be glad to arrange interview and consider reasonable offer regardless of location. Age 24. Married. No children. Robert Willis, Box 203, State College, Miss.

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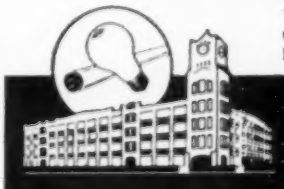

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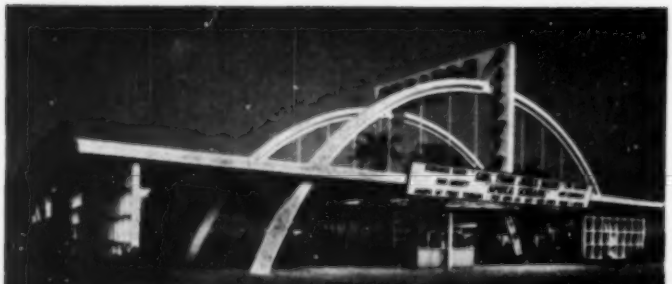

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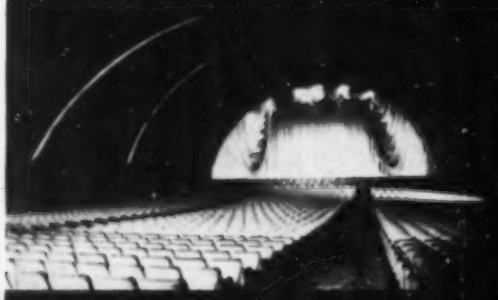

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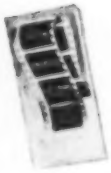

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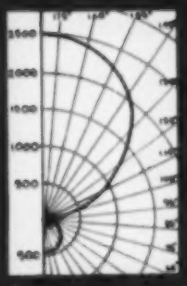

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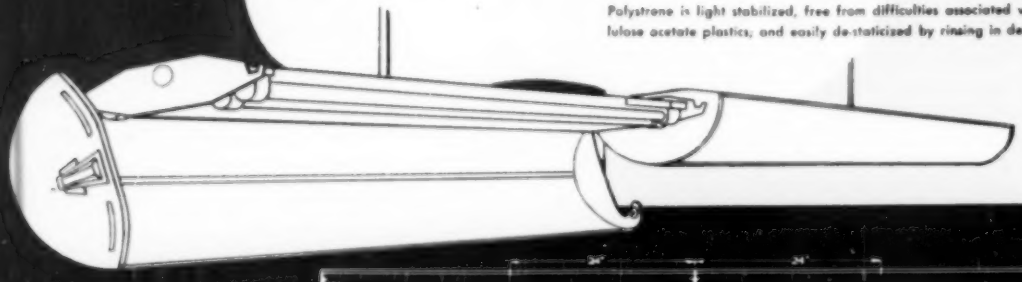
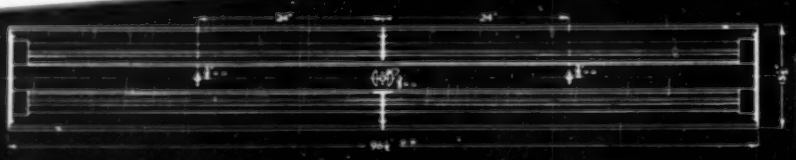
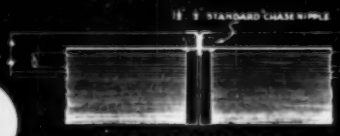


End view shows how curved plastic panels in metal frame can be swung open or detached; also knockouts, and other data.





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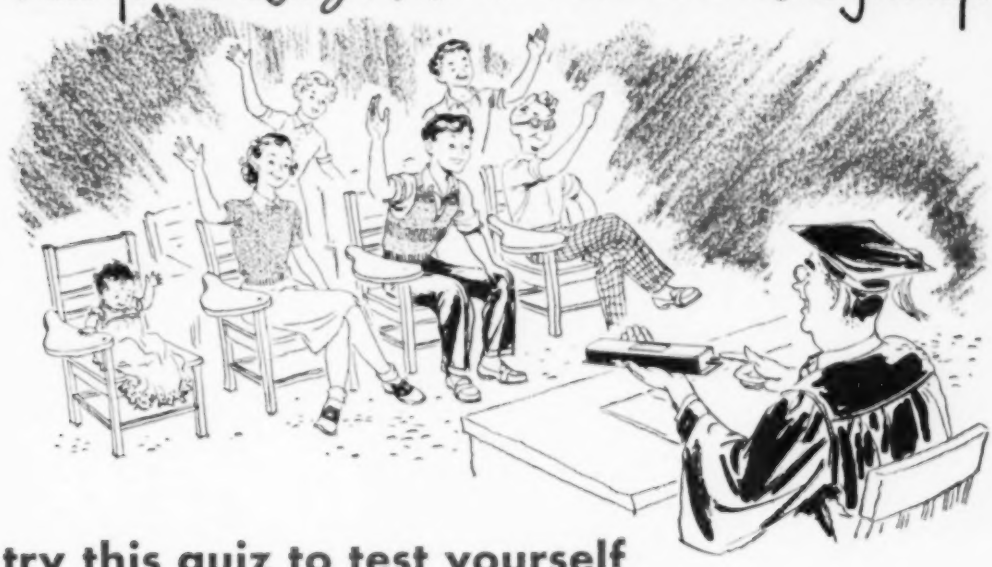

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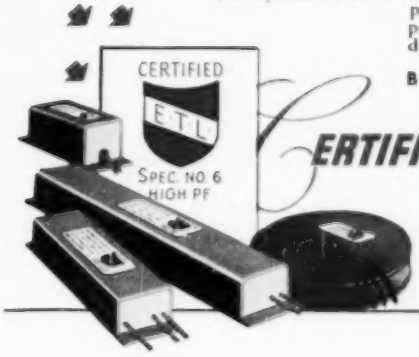

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